

FUTURE APPLICATION OF AQUACUL- TURE AND MARINE BIOTECHNOLOGY TO THE NATION'S ESTUARIES AND COASTAL WATERS

HEARING

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

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FUTURE APPLICATION OF AQUACULTURE AND MARINE BIOTECHNOLOGY TO THE NATION'S ESTUARIES AND COASTAL WATERS

MONDAY, MAY 15, 1989

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE
RESEARCH AND ENVIRONMENT,
Baltimore, Maryland

The subcommittee met, pursuant to notice, at 1:45 p.m., in the Knott Harbor View Room of the National Aquarium, Inner Harbor, Baltimore, Maryland, Hon. James H. Scheuer [chairman of the subcommittee] presiding.

Mr. SCHEUER. The Subcommittee on Natural Resources, Agriculture Research and Environment will come to order.

First, I want to express my appreciation to the Governor and the Mayor for their help in setting up this hearing. Second, I want to express my admiration for the Governor and the Mayor for having created and maintained the momentum for this magnificent marine environment in which we find ourselves today. It is a thrilling sight. It is one of the great urban jewels in our country.

The Governor is due enormous credit for his leadership and drive over many, many years in bringing this project to the point where it is today. The Mayor is to be equally commended for his picking up of the baton and running with the ball and maintaining the momentum. I think this reflects marvelously on both the Governor and the Mayor, this very exciting enterprise here, and on the citizens of Baltimore who have supported it, so I am particularly pleased for their help in setting up the hearing and want to commend them for this magnificent job of leadership.

Now, today the subcommittee is going to be considering the potential for marine biotechnology and aquaculture to improve the productivity and health of our Nation's estuaries and coastal waters. Estuaries and coastal waters are the most productive waters in our country, and about 70 percent of all our fish and shellfish which we harvest come from these coastal waters.

Unfortunately, for centuries we have treated our coastal waters with neglect and indifference, and we have treated them as sewers for our industrial, agricultural, and residential waste. For the relatively small and rural populations of the 19th and perhaps early 20th centuries, this caused very little problem. The great bays and estuaries of our country once had the capability to renew themselves and clean themselves.

But as the coastal area's population and as coastal area commerce has mushroomed over the last 20 years, these practices and these burdens have overwhelmed the bays' natural defenses and their capacity to rejuvenate themselves and spring back. Today nearly 50 percent of the American population lives within 50 miles of a coastline, and by the year 2000 the percentage of people living within a 2-hour drive of a coastline could be as high as 75 percent, so it is increasingly clear that the future health and productivity of our estuaries and coastal waters is very gravely at risk.

In 1985, one-third of the shellfish beds found in the United States were considered unsafe for shellfish harvesting. Now, that is a national disgrace. Obviously we need to take stronger steps to control pollution, but we also need to manage the resources of the bays and estuaries with far more wisdom and far more scientific knowledge than we have now.

Marine biotechnology is a relatively new science, but it offers the Nation and the world innovative technology that could improve the health, not only of our marine waters but also of marine waters around the world, and thereby improve and enhance the health of the world's population—a growing, in fact burgeoning, population, especially in the Third World. Research from this field of science, this new, emerging field of science, could lead to the development of new pharmaceuticals, increased food production, disease-resistant shellfish like oysters and other species, and oil-consuming bacteria. Think of what a blessing it would have been in the last month or 6 weeks if up in Alaska, in Prince William Sound, we had had oil-consuming bacteria technology available. The potential is vast, extraordinary, exciting, and challenging.

Seafood production through much of the world has been rapidly expanding, and the primary reason for this surge is aquaculture or mariculture research and development. That means farming the sea, just as we farm the land, intensively. Aquaculture provides an enormous potential for areas not only like the Chesapeake Bay here, but Long Island Sound where I come from, and I am proud to be a member of the Long Island delegation. Indeed, aquaculture is an absolute necessity for areas like the Long Island Sound and the Chesapeake Bay, for them to regain and enhance the leadership in fish production and in shellfish production which they have achieved.

Now, at this time I would like to turn the gavel over to my colleague, Tom McMillen, from the great State of Maryland. I want to really commend Tom McMillen for his leadership on this issue, as well as many others. He has been a leader not only in marine biotechnology but space commercialization, computer security, and environmental quality and a whole host of others. He is truly a hard-working, diligent, serious, productive, and creative Member of Congress. Congressman Mfume and I are proud to be his colleagues.

Herewith, I would like to turn the gavel over to you, Tom, and ask you to chair the hearing.

Mr. McMILLEN. Thank you very much, Mr. Chairman. I am again grateful for you coming back to the State of Maryland, as you did last year when we had a medical waste hearing with regard to the Chesapeake Bay. I thank you for coming back to our State to look at the future application of marine sciences, and espe-

cially marine biotechnology and aquaculture. I am glad you could come here today. New York and Maryland share some similar kinds of potential, as well as similar problems, so it is important that we can seek to find some answers to these questions as we move forward.

I am also pleased that my colleague from Maryland, Kweisi Mfume, could be here. Kweisi is a member of the Banking Committee, like myself, as well as a member of the Small Business Committee. I will defer to you in a minute for a statement, if you would like. We are also expecting another colleague from Maryland, Ben Cardin, momentarily.

I have a statement but, for timing's sake, I will ask that it be inserted in the record, but let me just say that there is so much about the marine science disciplines to improve the health and productivity of our marine waters that we are seeking to know. Really, the purpose of this hearing today is to not only unveil a very, very important project for the State of Maryland as well as for our country, but to look at the potential for marine sciences for our State and Nation's future.

We have all read about all the wonderful innovations of microorganisms able to digest oil, and fish that have antifreeze capacity, that can survive in cold temperatures, all these wonderful innovations due to science and technology which are really the foundation for our country's future. The same is really true of this burgeoning field of aquaculture, which can be very simply defined as planned cultivation and production of seafood.

Largely through the efforts of the United States Department of Agriculture, this area of aquaculture has been growing at a considerable rate over the last few years, at an average of 20 percent annually since 1980. It has tremendous implications for the State of Maryland with regard to our oyster production and our other seafood production, but while we look at the potential for exponential growth in these areas, we also have to understand the risks involved and we also have to understand some of the problems involved with other interests in these areas.

That really is the purpose of this hearing, to take a look at the overview of marine sciences, how we can better coordinate Federal research efforts. We can look at our current resource allocation to see if it is proper and appropriate for the future but, most important of all, we are looking at an international competitiveness issue. Will the United States of America, will the State of Maryland be prepared to meet the challenges that we are going to face internationally in the years to come? I know that we will have some testimony on that fact.

I don't know how many of you saw the Baltimore Sun on Saturday. There was a great editorial about the project that is to be unveiled today, but at the end of that it said that Christopher Columbus was himself subsidized by his government.

[Laughter.]

I thought that was kind of ironic, because what we are here talking about today is a Federal-State-local-private partnership to really take Maryland and our country to the forefront in these areas.

Without further ado, why don't I turn it over to my colleague, Congressman Mfume, and see if he would care to make a remark.
[The prepared opening statement of Mr. McMillen follows:]

OPENING STATEMENT OF REP. TOM McMILLEN (4-MD)
BEFORE THE SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURAL RESEARCH, AND THE ENVIRONMENT
(HOUSE SCIENCE, SPACE, AND TECHNOLOGY COMMITTEE)
REGARDING THE FUTURE APPLICATIONS AND POTENTIAL OF
MARINE BIOTECHNOLOGY AND AQUACULTURE

Mr. Chairman, members of the subcommittee, ladies and gentlemen, I welcome you to the Inner Harbor of Baltimore, Maryland for today's Congressional hearing on the future applications of marine sciences, especially marine biotechnology and aquaculture, to the nation's estuaries and coastal waters.

To be unveiled today at this hearing is an exciting new marine science initiative that is sure to fire the imagination of the public, as well as the scientific and research communities. A collaborative effort of international proportions, this project will certainly strengthen this country's resolve to lead the way in developing the resources, and harnessing the potential, of the world's oceans and waterways.

There exists so much potential for the marine science disciplines to improve the health and productivity of our waters. Advances are being made in these exciting areas each day, changes that could have a profound effect on the way that we lead our lives. We have all read about that miraculous microorganism that actually consumes certain marine toxics, including those found in crude petroleum. Another new development is a genetically altered fish that essentially has its own "antifreeze," allowing it to survive better and reproduce in colder waters. Probably few are aware that these exciting accomplishments were made because of years of careful study, much of which was done in association with the federal government.

The same is true with respect to the burgeoning field of aquaculture, which can be defined simply as the planned cultivation and production of seafood. Largely through the work of the U.S. Department of Agriculture's five regional aquaculture centers, much has been accomplished in recent years. Aquaculture production has increased on average almost 20% annually since 1980, with over 40% of our oyster production coming from these advanced techniques. Currently, total U.S. aquaculture production tops 400 million tons yearly. This translates into an industry whose value exceeds \$650 million a year. State-of-the-art breeding and aquafarm management techniques are continually being refined by these USDA aquaculture research centers, all of which provide an important outreach function to the aquaculture community.

While we have experienced almost exponential growth in the productivity of the marine biotechnology and aquaculture fields, many issues remain unresolved. It is for this reason that I suggested to Chairman Scheuer of the Natural Resources Subcommittee and to Chairman Roe of the full Science Committee that a field hearing would be appropriate, especially here on the shores of the nation's largest and most productive estuary, the Chesapeake Bay. In the course of today's proceedings, I hope that we will begin to better define the course of the federal government's involvement in these scientific arenas. It is my hope that this hearing will

serve to provide us with an overview of the marine sciences - past, present, and future. Today, we will hear from expert witnesses on how best to coordinate federal research efforts with regional academic endeavors. We will examine if our current resource allocation -- money and manpower -- is optimal, and whether or not we are doing an efficient job of disseminating technical information. Further, we need to address in this public policy forum the possible negative ramifications that might result from moving briskly forward in funding marine science research initiatives. Invariably, not all directives emanating from Washington and the federal bureaucracy are always popular with all segments of the population. Our job here today is to learn from interested individuals so that we may instruct the Science Committee, as well as the whole Congress, on the best way to proceed.

Certainly our work is cut out for us in the years and decades ahead. Concerted efforts are needed in order to conscientiously exploit the vast potential of the oceans to better the human condition and to maintain our delicate ecosystem. Let us use the occasion of this gathering to reaffirm our commitment to progress in the area of marine sciences. Without further adieu, let us move forward with today's proceedings.

Mr. MFUME. Thank you very much, Tom. I would like to just take a moment. Mr. Chairman, I would ask unanimous consent that my remarks in full would be entered into the record.

I would like to thank Congressman McMillen for being so insistent, as he has been on the Committee on Science, Space, and Technology, that the Committee consider convening here today for the purpose of looking at this project and how it will not only benefit this area, the Chesapeake Bay and the Mid-Atlantic region, but how it benefits America.

I am particularly happy that Chairman Scheuer decided to in fact convene this hearing here today. Jim and I serve together in the Subcommittee on Narcotics, and it is from that interaction that I have grown aware of his tremendous enthusiasm and the sense of urgency that he brings to matters that he believes in. To listen to him preface this hearing with his remarks was encouragement to me, and I would simply offer it as encouragement to you, that you have here a very qualified and capable, honest and committed chairman, who is looking at an issue obviously that we all care about, but obviously also I think generates within him a great deal of desire and a great deal of excitement.

Mr. Chairman, we are certainly happy to have you here today. You are going to be hearing from the chairman of the Christopher Columbus Center, the chairman of the Inner Harbor management team, our Mayor, our great Governor who has just arrived in the back there, and a number of other people who have signed up as witnesses today, who I am sure are going to bring, in the way they do best, the sense of urgency but, more importantly, the sense of possibility that exists in this project and why it is so very, very important.

The difference between us and Queen Isabella is that I think we have a few more resources and we take a reduced risk. She didn't know what she was really getting into. The Government of this country understands there is a tremendous potential for positive impact for generations to come, if we in fact get behind this project as we should.

So I thank you for being here, Mr. Chairman, and with that I will yield back the balance of my time.

Mr. McMILLEN. Without further ado, why don't we move to our first panel? What we are going to do today is unveil an exciting new marine science initiative that is sure to fire the imagination of the public as well as the scientific and research communities.

We have two witnesses here in the first panel: Mr. Alfred Copp, the director of Charles Center-Inner Harbor Management, Inc., and Mr. Stan Heuisler, chairman of the Christopher Columbus Commission as well as the co-Chair of Maryland 1992. For time's sake it would be appropriate that, if you wanted to summarize your testimony, the whole of your testimony will be included in the record without objection.

STATEMENT OF MR. STANLEY HEUISLER, CHAIRMAN, EXECUTIVE COMMITTEE, THE CHRISTOPHER COLUMBUS CENTER

Mr. HEUISLER. Thank you. I am Stan Heuisler. I am going to be chairman of the Executive Committee that manages the develop-

ment of the center. There are eight people, four appointed by the Governor and four appointed by the Mayor of Baltimore.

I think that the real strength of this is that it reflects the vision of Christopher Columbus. You know, when Columbus set sail, the people of his time sort of filled the parts of the map, the seas that were uncharted, with dragons. With each voyage, with each bit of knowledge, those dragons were pushed away.

Well, we are here to do a little dragon-pushing in Baltimore. We not only want to set up a world-class scientific institution—and it is sort of unarguable that the resources we have here are in leadership—but we want to share it with the world. Part and parcel of our project is not just that science present sort of a lonely face to people. People will be able to come into the center, they will be able to see work being done, on exhibition. They will be able to be touched by our maritime past, and they will be able to draw on this and move into the future.

The Columbus Center, we feel, is as unique and inventive and scientifically well-grounded as the man it is named after, and like Christopher Columbus, it symbolizes that daring pays off. This is, after all, a rare, perhaps unique high-tech campus placed in the middle of a major American city. This symbolizes something to the residents of this city and this State. This symbolizes that the high-tech future is available to people, and it symbolizes to them that they are part of that kind of future.

In the Baltimore-Washington corridor, this is the biotech capital of the world. NIH to the south, Hopkins to the north, and the University of Maryland system scattered in between. Here we have a treasure-trove of maritime history for marine archaeologists. The Chesapeake Bay—and this is one of those unknown parts of history—was called the Bahia de Madre de Dios by Spanish sailors here on the Bay 70 years after Columbus discovered America.

But I think best of all we bring scientific resources, we bring energy, we bring an enormous track record, but most of all, I think, Baltimore and Maryland are committed that this center in 1992 really send a message. You know, historical moments like the Columbus Quincentenary offer us a chance to both pause and reflect on our past and draw on our past as a point of departure to the future.

In 1893, on the 400th anniversary of Columbus' voyage, there was a Columbian Exhibition in Chicago. Americans from all over went there, and they saw elevators and skyscrapers and all the amenities of modern urban life that we now take for granted. That exhibition changed the face of America.

In 1992, we live in a global universe, we live in a global marketplace, and we communicate instantly. We think that this Columbus Center will be an important part of what promises to be one of the major, worldwide celebrations of the 20th century. In fact, because we are committed to make this a world-class piece of architecture, we think it will serve as one of the major symbols throughout the world.

In 1992, we want all the people all over the world to look at Baltimore and Maryland and see, in biotechnology, in underwater archaeology, not just the face of the future in science to solve their problems, but a friendly face of the future. We also want the Chris-

topher Columbus Center to send a message that America will not just compete in the international marketplace, but that we will lead.

That is a spirit we think does homage to Columbus, and that is a message to inspire all Americans in 1992. Let us not forget that the 21st century starts only eight years later.

We thank you very much, and I would like to ask that my other remarks be put into the record.

Mr. McMILLEN. Without objection, so ordered.

[The prepared statement of Mr. Heuisler follow:]

TESTIMONY ON
THE CHRISTOPHER COLUMBUS CENTER
OF MARINE RESEARCH AND EXPLORATION
FOR THE SUBCOMMITTEE ON NATURAL RESOURCES
AGRICULTURE RESEARCH, AND THE ENVIRONMENT
OF THE U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

MONDAY, MAY 15, 1989
THE WORLD TRADE CENTER
BALTIMORE, MARYLAND

BY STANLEY HEUISLER
CHAIR, EXECUTIVE COMMITTEE, THE CHRISTOPHER COLUMBUS CENTER
PRESIDENT, COLUMBUS 500/BALTIMORE
CO-CHAIR, MARYLAND 1992

When Columbus and others of his time set sail, the unknown parts of their maps were filled with dragons. Map makers of the time filled in uncharted waters with sea beasts and monsters that devoured ships and terrorized sailors.

With each voyage, with each bit of knowledge added, the dragons -- and our fears of the unknown -- were pushed off the maps.

Today, in Baltimore and Maryland, we're ready to push a few dragons of our own.

The Christopher Columbus Center of Marine Research and Exploration is a unique facility combining preeminent research and exhibitions of the marine world.

The partnership of city, state, federal, public and private interests working within the Center is ready to explore today's uncharted waters: how the very world itself fits together. To do this, our partnership goes back to the seas that spawned us and down to the very building blocks of nature to do it.

Scientists at our center will seek a better future in health, the environment, new industrial products, and aquaculture.

And to inspire us, the Christopher Columbus Center will draw on our maritime history and focus on the seas around us. We'll bring to surface and display treasures of our maritime past. We'll showcase marine life of today. We'll

be working every day in nearby waters on a cleaner, more productive marine environment of the future.

We'll also push back the dragons by sharing our discoveries with millions of yearly visitors at our center.

The Christopher Columbus Center in Baltimore is committed to science solving the world's problems, and spawning new economic growth. Our center for marine biotechnology will have an incubator facility to spin off businesses from discoveries. Our center of underwater archaeology will also work with marine robotics and other technological breakthroughs.

Add to that work a high-sensory "Smithsonian of the Seas" maritime center, a Marine Mammal Pavilion, and a conference facility, and you have a project like no other in the world.

The Christopher Columbus Center is as unique, and inventive, and scientifically well-grounded as the man it is named after.

And like Columbus, it sends the message that daring can still produce rewards.

Our biotech and underwater archeology centers will locate a hi-tech campus with economically-relevant brainpower in the center of an American city. It offers the citizens of our city and state a vivid new symbol of a global, technology-based future and signals increased possibilities and access for Baltimoreans and Marylanders in that future.

To the world the Columbus Center demonstrates an absolute commitment to American preeminence in a high stakes global game. "At risk," said the Wall Street Journal, recently about biotechnology, "is the early U.S. lead in the century's third great technological revolution -- after atomic energy and computers."

The participating organizations in our project all burn with the energy of a moment when Columbus's lookout saw light on the horizon, and then land, and the world was changed. At the Christopher Columbus Center in Baltimore we -- city, state, federal, public and private interests -- say that kind of flame still beckons: in imagination inspired by maritime history; in scientist's creativity; in the eyes of the next generations of children who visit our Center, catch our spirit, and set sail towards some new horizons of their own.

Why such a unique project here? Columbus wasn't born in Baltimore; he didn't discover the Chesapeake. But we think our Center demonstrates he'd fit right in locally. Intense, romantic, bright, impatient, active -- he's our kind of person.

This is, after all, a city that has in three decades reinvented itself by coming back to its own maritime roots. Look around you today and feel the energy: our Inner Harbor attracts more visitors each year than Disneyworld.

This is, after all, a state founded by voyagers in ships only a little larger than Columbus's Santa Maria, a

state whose very soul is its most precious natural resource, the Chesapeake Bay.

In the Baltimore - Washington Corridor is the biotech capital of the world: NIH in the south, Johns Hopkins in the North, and the University of Maryland system scattered throughout our State.

Here exists a treasure trove of maritime history for our Center of Marine Archeology. The Chesapeake was called "Bahia de Madre de Dios" by Spanish sailors here only seventy years after Columbus's voyage. Much of our country's subsequent maritime history was played out in local waters.

We have a special sense of history. We have the setting, the spirit, and a stunning recent track record for development.

The Christopher Columbus Center for Marine Research and Exploration is founded around scientists and researchers already preeminent in their fields. And our City and our State have already demonstrated extraordinary fiscal support for the Center.

Best of all, we're already under way.

The Center for Marine Biotechnology is already at work, today, two blocks from where we sit.

The executive committee of the Columbus Center will begin next week to select an architect for our complex.

The Marine Mammal Pavilion is on line to open in 1991.

We're nationally-recognized as leaders in the 1992

commemorations. We'll fill our bay with the Tall Ships of the Grand Columbus regatta in 1992. We will create a "Discovery Class" in local public schools with enrichment programs in languages, geography, and social studies. We're working with the twelve-nation European Community to stage a local trade/cultural exposition in 1992 to celebrate European unification.

And the Christopher Columbus Center for Research and Exploration has already been sanctioned as an official project for 1992 by the President's Christopher Columbus Quincentenary Jubilee Commission.

We think 1992, especially 1992 at the Columbus Center in Baltimore, helps send an important message.

Historical moments, after all, offer us a pause to examine our past and act as a point of departure for the future.

In 1893, on the 400th Anniversary of Columbus's voyage, there was a Columbian exhibition in Chicago. Americans saw there on display for the first time elevators and skyscrapers and most other amenities of modern life we now take for granted. The exhibition changed the face of America.

In 1992, the 500th anniversary of Columbus's voyage, we move in a global marketplace, we communicate instantly worldwide, and this center in Baltimore will be a prominent part of what promises to be one of the major celebrations of the 20th Century. In fact, given our commitment to

world-class architecture for the Center, we think it will become one of the most widely-recognized symbols of 1992 throughout the world.

In 1992 we want people all over the world to look to Baltimore and Maryland and see in biotechnology and aquaculture and other practically-applied sciences an important part of their future.

We also want the Christopher Columbus Center to send the message America will not just compete in the international arena -- it will lead.

That's a spirit which does homage to Columbus.

That's a message to inspire us in 1992. After all, the 21st century begins only eight years later.

Mr. McMILLEN. Thank you, Mr. Heuisler.

Mr. Copp, if you would care to summarize your remarks.

STATEMENT OF MR. ALBERT M. COPP, PRESIDENT, CHARLES CENTER-INNER HARBOR MANAGEMENT, INC.

Mr. COPP. Thank you. Thank you for the opportunity to speak today about the Christopher Columbus Center.

The Inner Harbor of Baltimore is probably the most appropriate place in the world for such a center. The Inner Harbor is visited by over 20 million people a year, two million of which go through the Baltimore Aquarium and the Science Center. We have ships of maritime history. We have a maritime focus that is seldom seen in a small harbor of the United States.

One of the real secrets of the Inner Harbor, however, is the deftness with which it uses educational attractions to provide a richness of experience to the visitors who come here. I would like to take a few moments, if you would, at the model and point out the buildings we are talking about, describe how they work together, and then my remarks would also be submitted for the record.

Can I ask you to come over?

Mr. McMILLEN. I would like to make an introduction before going any further. Our great Comptroller, Louis Goldstein, who actually was here when Christopher Columbus—

[Laughter.]

And if not, he was certainly here when this scene of Baltimore was present.

We also have the Governor and the Mayor here, if they would like to join us.

Mr. COPP. First of all, I would like to orient you. This is not a picture of the entire harbor; it is only of one pier. The National Aquarium that we are sitting in today is located just off the map, and then the first pier that we see is the Marine Mammal Performing Center which is under construction today. That, plus all of the facilities on Piers 5 and 6, constitute the Maritime Center as we talk about it. This is Harrison's 70-room urban inn and family restaurant that will open this spring, with the performing arts tent already in existence at the end of one pier, and the Seven-Foot Knoll Lighthouse has been relocated from the center of the Chesapeake Bay onto the end of Pier 5, where it will be renovated and used as part of a public education program.

The important part of this model, however, is what you see right in front of me. The two tall towers on Pratt Street at the end of the pier, this is the Center of Marine Biotechnology. It constitutes two buildings because one phase will be built to house the laboratories and the facilities today, and then a second building is scheduled to house spin-off corporations and serve as expansion space. There will be a conference facility down on the plaza above a parking garage, and then just to the outside around the plaza will be a maritime museum center where all of the focus of the two towers and other parts of the Inner Harbor will be shown to the public. This is really the public facility part of the project.

There is an Archaeology Center in a separate building on the pier, which is very close to the slip that will allow ships to come in,

bringing exhibits to the Archaeology Center. That will be open to the public also.

You can see that the entire pier will be part of the Maritime Center. There will be controlled access to the towers by the public. There will be controlled access to the Archaeology Center. There will be full public access to the Maritime Center that is on the plaza.

Now we can go back to our table, if you like.

I would just conclude that the Christopher Columbus Center of Marine Research and Exploration is the right project, the City of Baltimore is the right place, and today is the right time. Thank you very much.

[The prepared statement of Mr. Copp follows:]

Testimony of Albert M. Copp, President of Charles Center - Inner Harbor Management, Inc. to the Natural Resources Subcommittee of the House Science and Technology Committee

Mr. Chairman and Members of the Subcommittee:

I want to thank you for coming here today to receive testimony concerning a project of national stature and incalculable statewide and local value.

The Christopher Columbus Center could not be located in a more appropriate location in the United States. The Inner Harbor of Baltimore is the model of urban waterfront development throughout the world, and as such, guarantees a setting which will be visited by millions of people per year.

One of the secrets of the Inner Harbor is the seriousness with which it uses educational attractions to provide a richness of experience to its visitors.

The National Aquarium at Baltimore and the Maryland Science Center each year serve over two million visitors who come to learn about science and the natural world.

The Constellation, Pride of Baltimore, USS Taney, Chesapeake, Torsk, Lady Maryland, Minnie V Skipjack, all important ships of the sea, are pointed lessons in maritime history.

The Chesapeake Bay and Lady Maryland Foundations and other local programs introduce thousands of school children to the significance of the Bay's ecology through on the water, hands-on experiential learning. In the fall of this year, a new Maritime Academy will begin a job training program in maritime affairs ranging from shipbuilding to marina management for students of all ages from every economic and social background.

Indeed, the Inner Harbor has become a great public space which abounds with recreational, cultural and educational opportunities enjoyed by more than 23.0 million people each year. The Christopher Columbus Center, which is designed to bring the working frontiers of science directly to the public, could not be located in a more appropriate location.

The site for the Center is the last major undeveloped parcel in the Inner Harbor. With the Marine Mammal Pavilion under construction on Pier 4, the Center will primarily be built on the 15-acre parcel of Piers 5 and 6.

Already on the site and serving the Center are the 70-room Harrison's Inn and Restaurant, the Seven-Foot Knoll Lighthouse and the Pier 6 Concert Pavilion. All of the rest of the 15-acre site will be devoted to the Christopher Columbus Center.

The tall tower at the northern edge of the site will contain the laboratories of the Center of Marine Bio-Technology. The smaller tower will house private spin-off corporations engaged in marketing products developed through the Center. It will also provide expansion space for the Center itself.

Beneath the towers will be a 1,000-car parking garage built by the City of Baltimore.

Within the complex, but separate from the towers, will be a state-of-the art conference center which will serve not only the Center's symposia and conferences, but will also host maritime educational programs for a spectrum of institutions ranging from elementary schools to professional technical societies.

The smaller separate structure will house the Center of Marine Archaeology's laboratories and teaching facilities, public exhibition space and specimen aquarium facilities. These aquarium facilities are located near the water so as to allow them to be periodically renewed by fresh sea water pumped from tankers in the adjacent slip. The slip will also be used by marine research vessels of all kinds.

On the central plaza will be the Maritime Center or better said the Maritime Exposition Gallery.

This structure will have both permanent and changing exhibits produced by existing public and private institutions and corporations.

The Center for Marine Bio-Technology and the Underwater Archaeology programs will have their major permanent and changing exhibits here to give the public an understanding of the most current state of research in these areas.

Throughout the Christopher Columbus Center, provisions will be made for direct controlled access of the public to witness work in progress. This direct interface between the public and the conduct of working science is an essential design principal of the Center which will make it unlike any other research institution in the world.

It is fitting that this Center of Discovery will come about through an inter-governmental partnership which brings together the very real and pressing interests of the United States, the State of Maryland and the City of Baltimore in our mutual economic well being and in the universal need to bring the understanding of science to everyone.

The Christopher Columbus Center of Marine Research and Exploration is the right project, and the City of Baltimore is the right place, and this is the right time.

Thank you for your time and your consideration.



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May 15, 1989

Mr. McMILLEN. Thank you very much.

Before we begin, I would like to thank Nick Brown for allowing us to use the National Aquarium here, and before we get into questions I would like to defer to my other colleague from Maryland, Ben Cardin, whose district actually encompasses these facilities, if you have an opening statement, Ben.

Mr. CARDIN. Well, first let me thank my colleague, Tom McMullen, for bringing this hearing to the Third Congressional District of Maryland and the Harbor of Baltimore. I also would like to welcome the chairman, Jim Scheuer, to Baltimore. Jim is a real leader in the Congress of the United States on the importance of biotech and the importance of caring for our water. He is a good friend. He is a good friend to urban centers, and I am particularly proud that he would bring the hearing to Baltimore. On behalf of the people of our State, Jim, we thank you very much for this opportunity to make this presentation.

I understand that the panel is in the midst, now, of making the presentation concerning the Columbus Center. We think we have one of the best spots in the country here in the Harbor of Baltimore. We are very mindful of the commitment that we have to protect our water resources and our environment.

Indeed, the State of Maryland under the leadership of Governor Schaefer and the City of Baltimore under the leadership of Mayor Schموke, have imposed, I think, tremendous commitments on behalf of the citizens of Baltimore to the protection of our environment. We have in fact limited land use around our waters. We have imposed new agricultural commitments on our farmers. We have imposed additional restrictions on businesses located here, in order to protect our environment and our water resources.

Obviously the ingredient that we want to concentrate on today is the importance of biotech research in solving the problems of our water resources in this country. I am in complete support of the proposals that are being made today, and I welcome the discussions that will take place during these hearings.

Mr. McMILLEN. Thank you very much, Ben.

I just have one quick question, and then I can defer to my colleagues.

You have talked about the biotech potential for the State and the synergism of this facility with the Chesapeake Bay. Now maybe you could just touch upon the reasons for selecting the Inner Harbor as the site for this facility. Although it is obvious, I would like you to elaborate on that for the record, and then also discuss whether any other sites were looked at when you analyzed this.

Mr. HEUISLER. I think that it goes back to something. We are pointing towards 1992 because we think it is an international celebration, and certainly there is no more exciting metaphor, as the Congressman said, than sort of a waterborne rediscovery. Here is a city that really came back to its roots, that reinvented itself via the water. We want people to come to this center, and while the biotechnology is happening, and while the underwater archaeology is happening, and while the aquaculture is taking us into the 21st century, through exposition they can be borne forward.

There are, after all, more visitors to the Inner Harbor every year than Disney World, so millions and millions of people will come

and be touched by this technology, and it will become a friendly part of their future. That is the reason we think it is a logical extension of what the planners and the city have been working on for decades.

Mr. McMILLEN. Mr. Scheuer?

Mr. COPP. Let me speak to the second part of that question. When you take a look at the project and you understand that it needs a university presence, it needs public exposure, it needs a place of national reputation, there are very few places that fit those criteria as the Inner Harbor does. We looked around the State of Maryland, and felt that right downtown in the City of Baltimore was the place where something of national significance should be.

Mr. McMILLEN. Mr. Scheuer?

Mr. SCHEUER. No questions.

Mr. MFUME. No questions.

Mr. McMILLEN. Ben, do you have any questions?

Mr. CARDIN. No questions.

Mr. McMILLEN. I thank you all for agreeing to testify, and we will begin our second panel. Governor Schaefer is going to testify.

Obviously the Chesapeake Bay has been one of the priorities of your administration. In my two years in Congress, I can only say that your leadership and your advocacy of the Bay have been outstanding.

I think one point to note is, not only have you been interested in improving the water quality of the Bay—and that is so important—but also the productivity of the Bay's resource. There are a myriad of concerns, aquaculture being one of them. You have set up a State Aquaculture Task Force to examine the issue and the potential for Maryland.

But I think more important than that is, how can you shape aquaculture to meet the needs of the State, to make it available for the entrepreneurs in the State, to make sure that the future of aquaculture is not just limited to the corporate world. I think that you have done a terrific job of balancing the various interests here.

So without further ado, Governor, we are pleased that you could be here to testify on behalf of the Christopher Columbus Center.

STATEMENT OF HON. WILLIAM DONALD SCHAEFER, GOVERNOR OF THE STATE OF MARYLAND

Governor SCHAEFER. Thank you very much, Congressman.

Mr. Chairman, I am real, real pleased that you are here. This is the second hearing. The other one was on waste, and that is very important also.

When I look at what I am supposed to say, I think you could almost turn around and look at that map right behind you, that picture of Baltimore. When Baltimore was at the height of its commerce, the problems of pollution within the Bay and things like that never bothered us. We just decided that it was here forever, and you could dump trash and you could dump the waste from the ships off the side. You could let all the industrial waste come in.

Then we all suddenly found out that we were wrecking the Chesapeake Bay and we had to do something about it as soon as we

possibly could. The City of Baltimore, I guess, in a way took sort of a leadership. We had to do away with the pollution of the Bay, and we did. We went to all the industries and asked them if they would stop dumping all the trash and all this stuff in the Bay. We have been, I think, reasonably successful.

Why here? Why in the Harbor of Baltimore? Well, from my standpoint there is no question that the State of Maryland should be the place where it is located, and the Inner Harbor of Baltimore City is the proper place.

You asked the question, were other areas identified? We looked at other places, I am sure, but it should be here. You have noticed the expansion, all the things that have gone on, Johns Hopkins and the research that is going on there, so I won't draw on that point.

The great thing is, there is so much more to do here. We are not finished in the Harbor. There are many more things to do, like Mr. Harrison, the place that he is building over here, putting in a tremendous sum of money. He didn't have to come here, but he thought this was the place where he could make money and make a major contribution. That was good.

Mr. Mfume was here on the city council with me years ago, and Ben was down at the State House, and we have all worked together. I guess the thing that is working so well now is that cooperation between the Federal, State, and local government, and the private sector. It can't work without that, and it is working very well.

Now as far as restoring Chesapeake Bay, if I were you I would ask me, are we making any progress?

Mr. SCHEUER. Well, consider yourself asked.

Governor SCHAEFER. All right. Yes, we are. We really are. There is a tremendous amount of money coming in from the Federal Government and we are making progress. Someone said to me the other day, "You are just wasting your time, wasting your energies." I told them that was absolutely untrue. We do see an improvement. In fact, they just told me the other day, there are worms and organisms coming into the Inner Harbor. Now I didn't know how important a worm was until they told me, "As soon as you get worms in the water up here, you're set. That brings the fish in."

What I am saying is that the water quality has changed and it is working very well. We are doing something about it and we are going to continue to do it. Our commitment is not just today or tomorrow, it is from now on. We have a major program.

Aquaculture, it hasn't been easy with aquaculture. You have varied interests. You have the watermen, who think that possibly aquaculture is an infringement on them. They worry about what is going to happen or not. That was in the beginning. We are getting away from that now, to where there is a chance for both to survive, both to be able to make it. Aquaculture is a very, very important part of our industry, and we are going to work at that in the future. The same with rockfish, bluegills, yellow perch, white perch—all those fish, and the biotechnology is right here.

I guess you don't need any more from me. Is the State behind it? One hundred percent. Will we be able to do it? Yes. Can we do it on time? Yes. If we get the money from you, we will make our commitment from the State, and the Mayor will tell you he will make

a commitment from the city's standpoint. The private sector will support it. We will do it, we will do it rapidly. We will build it, and you will be proud of it, and that is all I have to say.

[The prepared statement of Governor Schaefer follows:]

TESTIMONY OF
THE HONORABLE WILLIAM DONALD SCHAEFER
GOVERNOR OF MARYLAND

BEFORE THE
HOUSE COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON
NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT
MAY 15, 1989

Good afternoon, today we are here to discuss the Christopher Columbus Center and its importance to the future. The future of the Chesapeake Bay, the future of aquaculture and the future of biotechnology.

The Center will commemorate the 500th anniversary of Columbus' discovery of the Americas, by embarking on a new voyage of discovery -- to discover the potential of our nation's waters. The mission of the center will be to develop new technology, as well as new ways of protecting and enhancing our nation's water resources.

The success of the Christopher Columbus Center will depend on a strong partnership, among all levels of government, private enterprise, and universities. Each has a role to play. Collectively through the Columbus Center, we can accomplish much more than we can do separately.

The potential benefits from the research conducted at the Center staggers the imagination. The biotechnological research will benefit our environment, our economy, and our quality of life.

Mr. Chairman, this Center offers so many potential benefits that it is difficult to summarize it in a few brief remarks. Today, I would like to look at several ways in which the Christopher Columbus Center will help not only Maryland but the entire nation.

As I am sure the members of this committee know, the Bay states of Maryland, Virginia, and Pennsylvania along with the District of Columbia and the federal government have been engaged in a major effort to restore the Chesapeake. After years of abuse and neglect, the nation's most productive estuary is in decline.

Our fisheries' harvests are a fraction of what they used to be. Oysters, shad, striped bass and perch populations have all been decimated. Fortunately, we have begun to respond to the challenge. Through the efforts of local, state, federal governments -- and most importantly, people -- we are making a difference.

For example, we have learned how to restore the striped bass population, and now we are beginning to see this fish come back. But much more needs to be done. The Christopher Columbus Center will provide the facilities to coordinate a broad range of research to help us to deal with the Bay's pollution problem.

We all recognize how difficult it is to strike a balance between progress and preservation. Part of our solution may be provided by the research that will be done at the Christopher Columbus Center. This spring, for example, we were all stunned and saddened by the oil spill in Alaska's Prince William Sound. 100 million gallons of oil resulted in hundreds of millions of dollars in clean-up costs and untold damage to the ecology of that area. Last year, we had an oil spill of our own. Fortunately, it was very small. As Congress and the states grapple with proposals to improve oil transport, we all have an uneasy feeling because there never can be a perfect system.

New research projects will help us deal with this problem. For instance, work is underway at the University of Maryland to develop a microorganism that will eat the deadly toxics in oil. Imagine that. This is the type of innovative research that the Christopher Columbus Center will promote -- research to protect not only the Bay, but all our waters.

The benefits the Columbus Center will bring to the Bay restoration effort don't stop there. One of the major commitments of the Bay Agreement is to restore the unique habitat that had supported huge populations of fish. We all want to enjoy the Bay. Unfortunately, locating our houses, towns, and cities on the Bay shore has dramatically altered its environment. This development and the waste products we produce have crippled

the capacity of the Chesapeake to support its living resources.

We need to change that. We need better waste water treatment and more effective nonpoint source pollution programs to bring back the habitat that the fish and other living resources need to survive. The Christopher Columbus Center's research can provide new technology to achieve these goals.

We will never again have the Bay that the Arc and the Dove found three and a half centuries ago. But research conducted at the Columbus Center can provide us with new ways to make the Bay productive and healthy again.

In addition, the Columbus Center will assist state and federal monitoring and management efforts. The Center will provide expertise to help chart our course and measure our progress.

The new Center will also help us improve fish migration. We all have a hometown that we live in or like to return to. For me it's Baltimore. Some fish, shad for example, also have a homing instinct that draws them back to the stream of their birth. Shad need to go back to their "hometown stream" in order to spawn. The water conditions in these streams affect the ability of the shad to return home. The Columbus Center will conduct research on how this homing instinct works, determine which shad go to which streams, and find ways to help the shad go home. This will

bring back the populations of this fish after years of decline.

The Center will also promote research into how we will get the most benefit from our ocean resources. Aquaculture is already an important source of food. In Maryland we consume over 63 million pounds of seafood annually. Per capita consumption of seafood is the fastest growing segment of the American diet.

Unfortunately, although Maryland borders the most productive estuary in the U.S., we import more fish than we export. With proper attention to aquaculture we can change that by working hard on both aquaculture research and marketing.

The Christopher Columbus Center has a role to play. The Center will conduct research on how to grow fish faster, improve spawning, expand harvests, and rid both fin fish and shellfish of the diseases that currently plague their populations. Work is already being done at the University of Maryland on developing a new bacteria that should help restore the oyster population.

Mr. Chairman and members of the committee I am excited about the prospects and about the future this new center will help usher in. The voyage taken five centuries ago need not end. This center will keep it alive. Its work will be our legacy for the future.

Mr. McMILLEN. That's enough. Thank you very much.
[Applause.]

Mr. McMILLEN. One of the things that I think is very interesting is, when you look at the National Science Foundation and their commitment to biotechnology, of \$82 million spent last year, only about \$100,000 of that was for sea life and for aquaculture and all that.

One of the problems that we have is, this has never been an area that the Federal Government has been very aggressive towards. Presuming that this facility can be built and so forth, do you have any views on the State's contribution to those continuing contributions to research and development of aquaculture?

Governor SCHAEFER. A major one, Congressman. In 1990, January 1990, is really the first time we will be moving forward. As I said in the beginning, and I didn't go into detail, it is not so easy to change people's habits—from watermen to aquaculture, from having leases on the Bay that have been active for years—going into all that. We are pushing hard on aquaculture.

Second of all, it is a major industry. It is a major industry for farmers, a major industry for watermen. It is a major industry for our State, so the answer is, there will be really a firm commitment as far as aquaculture is concerned. We are not as far advanced as I would like to see, but come January 1, 1990, when the law goes into effect, we will be moving.

There are rockfish being grown all over the Eastern Shore, and I mean big rockfish. We can't move with them yet because of the law, but come next year and we will be able to move. There is marketing going on at the University of Maryland.

So there is a great future for aquaculture—oysters, clams, fish. There is one thing that we have learned, though: preservation. You don't go out and catch all the rockfish in one year and then say, "There is no rockfish." You have to have an orderly process in order to make sure that you don't go back to where we were a number of years ago.

Mr. SCHEUER. That is what is known as sustainable yield harvesting, and that is true of fishing, it is true of harvesting the tropical rain forest. You have a capital resource, and you don't want to kill the goose that laid the golden egg. All over the world people are talking, and governments are pressuring the private sector to adopt the concept of sustainable yield. You don't take out more than nature can replace, because you don't want to kill the goose that laid the golden egg.

Governor SCHAEFER. That's what could happen here with rockfish in a very short time, if we just lifted the ban. Virginia just put the ban on, and we have had the ban and we will continue that ban for some time, I think. But it is a process where the watermen will be able to survive—those that can survive—and also we are very strong into aquaculture. But you also have a great industry, and this Mr. Harrison over here, when he testifies, he will tell you about his business on just taking fishing parties out, and the amount of money that comes into the State of Maryland as tourism.

The center itself will give us the background and the knowledge that we will be able to use to sustain aquaculture, to sustain those

rockfish. Are we over-crabbing? Are we over-catching the bluefish? All those I think this will come into it, so I can only assure you that we will do our part.

Mr. McMILLEN. Governor, another quick question on your idea of trying to encourage entrepreneurs and small business in this area. Obviously, as you know, there is a tremendous capital investment required, the feed is very expensive, and right now major corporate entities are the ones that are entering this field in an aggressive fashion. What could you do on a State level to try and encourage the small businessman?

Governor SCHAEFER. Remember what I said, it wasn't easy to get where we are because of the misunderstanding, the mistrust, whatever the term might be, between the watermen, the farmers, people who really don't know what aquaculture is. You have to build that trust. We can lend money. We can lend the watermen money to go into aquaculture. We really can. We can help them, and some of the ones that aren't going to make it, we can help them by buying them out and helping them with other areas.

Aquaculture just has a tremendous future. Pam Shriver's father is one of the leading men in aquaculture in Baltimore County. I didn't know this until the other night. He said, "I'm doing this, and I think I'm going to do well in this," and he is looking forward to this.

There are ways to get some mortgage money, there are ways to get some grant money. There are all sorts of ways, as soon as we just loosen up a little bit and understand that aquaculture is here, and if we don't move in Maryland, everywhere else is going to move, just move right by us. That is not going to happen, though.

Mr. McMILLEN. Mr. Chairman?

Mr. SCHEUER. No further questions.

Mr. McMILLEN. Kweisi?

Mr. MFUME. Governor, let me also thank you for taking time to be here today.

Tom said something earlier in his remarks to you, and that was to refer to you as one of the leading advocates, if not the leading advocate of the Bay. Most of our colleagues in the Congress are aware of the fact that the Bay is the country's most productive estuary. What they probably are not aware of is how hard you have worked to improve the quality of the water, the productivity of the Bay, and the preservation of marine life as we know it.

I have to again go back to my remarks about Jim Scheuer. It is good, I think, to have the chairman here and to hear firsthand from you the sense of enthusiasm that I think has infected all of us with this project, so that we may be able to go back and to spread that to others in the House of Representatives who could not be here today.

I think it is fair to say that obviously those of us who represent the State of Maryland are going to work very hard, in a very diligent fashion in Congress, working through the system of bureaucracy to try to get an appropriation for this, an adequate appropriation, so that we are in line with this 1992 target. Let me ask you, though, if you have given any thought—aside from the Federal appropriation—if you have given some other thought to the role that the Federal Government might play as you see it, perhaps with a

national designation which you were able to get some years ago for the aquarium, or in some other way as it relates to the project.

Governor SCHAEFER. I don't think any project of this magnitude can move forward without help from the Federal Government. No matter how much the State would put in or local would put in, you need that. You need that designation as a national. That bill that was put in designating us as a national aquarium allowed other areas to be national aquariums, also, but we were the only ones that really moved with it, and we have used it. Captain Brown back here, Nick has just done a super job. I drove up here, and the amount of people that go through this just to see fish—just to see fish.

One of the things that made this so interesting, years ago when we had this on the referendum, the question was whether some people were going to vote for it. The thing that I think passed the bill, there was a grandfather holding the hand of his grandson. I said, "Why are you going to vote for it?" He said, "For him." He was talking about the environment, talking about fish, talking about all the things that we are talking about today. People are interested now. They are up. Now is the time to do this. The appropriation from Congress will be a great help, but the enthusiasm from the State and the local government is equally important in order to sustain it.

Mr. MFUME. Thank you, Mr. Chairman.

Mr. McMILLEN. Ben?

Mr. CARDIN. I would just like the record to reflect that the Chesapeake Bay is truly a unique estuary. The work that we have done here, though, can be extremely useful in trying to help water quality in many other bodies of water around this Nation. The Clean Water Act which Congress passed recognized that, and made funds available to other areas so that they could use the Chesapeake Bay model to look at ways for reclaiming other areas of the Nation.

This project is truly unique, in that it provides for this region and the Nation the necessary research in our waters to complement the work that is being done by State and local governments, the national government and the private sector, and would have tremendous benefit beyond just the waters here.

Again, Governor, I want to thank you for being here. I think the record should reflect that we have a unique opportunity here that will benefit the Nation.

Governor SCHAEFER. Mr. Chairman, my short remarks did not reflect my enthusiasm. I did it out of saving some time, but if you would like for me to tell you about the Chesapeake Bay, you would have no time for anyone else

[Laughter.]

I could just talk about one million Marylanders, where we are going to get one million Marylanders. One million Marylanders are going to take part in the cleanup of the Chesapeake Bay. We have made people aware out as far as Allegheny County, the furthest county, Washington County, aware that they help pollute the Bay and they have to take an interest in this thing. We have to get everyone, as Louis would say, wherever he was, he would say, every time he would start talking about a ship that goes by, "Have you

got a station where you put the whatever it is?" You know what I'm talking about, where you put that.

[Laughter.]

So we are really pushing this Bay because we really believe in it, and what this will do, it will add that added dimension that will help us but also help the rest of the country. It is a great opportunity for America, not only for us but for America, and this is a great Bay. It is so great and so—well, I will leave it there.

[Laughter.]

Mr. McMILLEN. Thank you very much, Governor, for your testimony. The chairman said we should take an hour to hear from you, but—oh, well.

Mr. GOLDSTEIN. May I make one remark, Mr. Chairman?

Mr. McMILLEN. Yes. A minute ago I introduced our comptroller, Louis Goldstein. Louis?

Mr. GOLDSTEIN. It won't take but one minute. You asked will the State continue to put up appropriations. Well, the Governor and I will be here until January, 1991, and I think the voters of Maryland will probably send us back, so we will be here until January, 1995.

I can tell you Maryland is a rich State. Right now we stand fourth or fifth in personal income. We are right in the heartland of the greatest megalopolis in the world.

This Chesapeake Bay here, John Smith described it in 1608 and 1609 as "a delight to life," and I can assure you, sir, it is more of a delight today than it was when he came up here in a 34-foot shallow boat and made a map of this great area, and he described it in detail, the 26 major rivers, but we have all these estuaries flowing in there, too.

I know the Congressmen in Washington and the Senators, where do they come to recreate themselves? In the fall they come to go goose hunting, duck hunting, eat the delicious oysters, and they really work when they go back to Washington. In spring and summer they come to get the crabs and the bluefish and the fresh vegetables.

There is really no place in America like it, and I can assure you that we in Maryland will find the finances at the State level to match the Federal, along with the city and the others, to make this project one of the finest in the world. Another reason is, remember that Congress can come over here in 20 minutes at the most in a little helicopter and land right here and see what is going on, so they can go back and try to do the same thing in the great river basins of America.

I lived down in this Chesapeake Bay country. When I was a young boy, I used to steal watermelons, swim across this harbor here from 1918 to 1924. I was a pretty bad kid until my father grabbed me and put me back on that farm, on that Chesapeake Bay farm, catching oysters and fish, so I can tell you both sides of it.

We are going to make this the finest facility in the world. The University of Maryland, Johns Hopkins University, all of the State colleges—Coppin State, Morgan State— Washington College, other kinds of colleges, they will all be here doing this research work and bringing it into the harbor.

Thank you very much. I said I would only take a minute to say a few words after the Governor and all these other folks had made their statements.

Mr. McMILLEN. Thank you very much.

[Applause.]

Mr. McMILLEN. Although this Christopher Columbus Center is going to be a great resource, there is no greater resource that the State of Maryland has than our great comptroller, Louis Goldstein.

Our next witness is going to be the Mayor of Baltimore, Kurt Schmoke. Very briefly, as you know, the Mayor has presided over the City of Baltimore for the last year and a half and tried to lead the city into its second renaissance, focusing on education. I think this project has the opportunity to energize so many of our students. Particularly this Center of Marine Research and Exploration will be a vital resource for students, graduate students, postgraduates to learn about marine life and the relationships between man and the sea.

Mr. Mayor, we are pleased that you could be here.

STATEMENT OF HON. KURT L. SCHMOKE, MAYOR OF THE CITY OF BALTIMORE

Mayor SCHMOKE. Thank you very much, Congressman McMillen and Congressman Scheuer, gentlemen on the subcommittee. It is particularly gratifying to see you here, Congressman Scheuer. The last time that I testified before you it was a little bit different issue, but it was one of great challenge to our country. I know you are a man of vision and integrity, and I am so pleased that you are here. I join Governor Schaefer in welcoming you back to Baltimore, particularly to the Inner Harbor, and also now to Baltimore, the city that reads.

I would like to just follow up a bit on the comments that Congressman McMillen made. I submitted for the record testimony that explains some of the local and national benefits of the Christopher Columbus Center and Baltimore's contribution to the center, but I would like to supplement that testimony with a few remarks about science, education, and a city that is committed to advance the cause of both.

As you will no doubt hear many times today, the Center of Marine Biotechnology, that part of the Christopher Columbus Center to which the Federal Government is being asked to contribute, will be unlike any other science complex in the world. It will be a landmark in the field of science that holds out the promise of major advancements in health, environmental protection, food production, and national defense.

The Center of Marine Biotechnology offers the Federal Government the opportunity to assume a leadership role in developing lifesaving technologies. The investment we make today in the pure science of marine biotechnology will pay educational, economic, environmental, and medical benefits far into the future. To walk away from marine biotechnology, to leave it to some other country or some other time, will be a self-inflicted wound which our children and theirs will end up bearing.

For a moment I would like to focus primarily on those young people. One of the reasons that I am so enthusiastic about the Christopher Columbus Center, and strongly support giving the center perhaps the most valuable piece of property the city owns, is because of the impact I expect it to have on students.

I don't claim to be the education mayor, but I have put a very strong emphasis on public education and literacy. Our goal is to make Baltimore the city that reads, but we have to do more than talk, and talk about education. We even have to do more than increase local government spending on education, which we are nevertheless doing in Baltimore. We also have to inspire and lead and build national symbols.

I can remember back when Alan Shepard went up in his rocket for the first suborbital flight over the United States. That flight, and those of the other original seven astronauts, galvanized the thinking of an entire generation. Space flight didn't turn us all into astronauts, but it helped us to see the world as a place of possibilities, not improbabilities. How many children in 1961 said to themselves, in that sort of wide-eyed way that children do, "The astronauts succeeded, our country succeeded, and I can succeed, too." Mr. Chairman, I think there were probably quite a few.

So I very much want to see the Christopher Columbus Center built in Baltimore. It is not only going to provide highly skilled jobs, additional tax revenue, and valuable educational lessons for millions of people. It is going to be an educational beacon for the children of Baltimore, in fact for children everywhere. Baltimore will achieve its goal. We will be the city that reads, in part because the young people of this region will know that learning to read and think is the first step towards being able to work in a place like this Center of Marine Biotechnology.

The oceans today are as big a mystery as outer space, and exploring the underseas has the potential of providing practical and cost-effective products, so I very much hope that the Federal Government will become partners with the City of Baltimore and the State of Maryland and the private sector in studying and obtaining economic benefits from the world's vast and mostly unknown marine life.

As for the questions that you have about "Why Baltimore"? I can run down a number. I think the Governor has touched upon a few.

I also wanted to explain to you another aspect of the 1992 date that has not been mentioned thus far. I recently took a trip to Europe as a part of our sister cities program. One of the things I did is, I took a side trip to Brussels to make a presentation to the European Commission. In 1992, as you know, Europe is expected to become a single market, and we felt that it would be most important and significant if the EC could have an economic and cultural exhibition here in Baltimore to introduce the new Europe to the United States.

That proposal was very well received. We do not know yet what will be their final answer, but I think that is a significant development and one that I think would go a long way, with this new center, in showing and emphasizing the international aspects of this project.

Well, as you know, the investment, the combined investment by the city and State would be over \$122 million. No other region in this country has offered to make that kind of investment for this type of activity.

The Center of Marine Biotechnology is already located here in Baltimore. Some of the top scientists in the field, including Dr. Rita Colwell, are here, as are Johns Hopkins and the University of Maryland, both of which have leading programs in biotechnology.

The Center of Marine Biotechnology, by the way, moved its offices across the street to our Community College of Baltimore last month, but they are already bulging at the seams. They are one of the few research institutions that is actually turning away projects because of the constraints that are now imposed on them.

Baltimore, of course, sits on a great estuary, the Chesapeake Bay, and this center will help us in studying that estuary. The National Aquarium, it has been mentioned, attracts millions of people a year, and of course our proximity to Washington, D.C, the Department of the Navy, the National Institutes of Health, NOAA and other Government agencies dealing with the marine sciences, makes this a prime location.

Everyone here, public officials, the citizens of the region, are united behind this Christopher Columbus Center. It is the ideal research facility for this area, and we intend to work very hard to make sure that it benefits all of the people of the United States.

Mr. Chairman, let me again say I want to thank you again very much for coming to Baltimore. I look forward to that day in 1992 when the subcommittee and you can come back to Baltimore for the dedication and opening of the Center of Marine Biotechnology. Thank you very much.

Mr. SCHEUER. That's a date.

Mayor SCHMOKE. I appreciate it.

[The prepared statement of Mayor Schmoke follows:]

Testimony of the Honorable Kurt L. Schmoke
Submitted to
The U.S. House of Representatives
Subcommittee on Natural Resources,
Agriculture, Research, and Environment



May 15, 1989

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II. Additional Testimony Submitted for the Record

Opening Statement of Mayor Kurt L. Schmoke

Before the Subcommittee on Natural Resources, Agriculture,

Research and Environment

World Trade Center, Constellation Room

Baltimore, Maryland

Monday, May 15, 1989 at 2:00 P.M.

Mr. Chairman and Members of the Subcommittee:

I join Governor Schaefer in welcoming you to the Baltimore Inner Harbor and The City That Reads.

I have submitted for the record testimony that explains some of the local and national benefits of the Christopher Columbus Center and Baltimore's contribution to the Center.

But I would like to supplement that testimony with a few remarks about science, education and a city that is committed to advance the cause of both.

As you will no doubt hear many times today, the Center of Marine Biotechnology - that part of the Christopher Columbus Center to which the federal government is being asked to contribute - will be unlike any other science complex in the world.

It will be a landmark in a field of science that holds out the promise of major advancements in health, environmental protection, food production, and national defense. The Center of Marine Biotechnology offers the federal government the opportunity to assume a leadership role in developing life saving technologies. The investment we make today in the pure science of marine biotechnology will pay educational, economic, environmental and medical benefits far into the future.

To walk away from marine biotechnology - to leave it to some other country or some other time - will be a self inflicted wound which our children - and theirs - will end up bearing.

For a moment, let us focus primarily on those young people. One of the reasons that I am so enthusiastic about the Christopher Columbus Center - and strongly support giving the Center perhaps the most valuable piece of property the City owns - is because of the impact I expect it to have on students.

I don't claim to be the "Education Mayor," but I have put a very strong emphasis on public education and literacy. Our goal is make Baltimore The City That Reads. But we have to do more than talk about education. We even have to do more than increase local government spending on education - which we are nevertheless doing in Baltimore.

We also have to inspire, and lead, and build national symbols. I can remember when Alan Shepard went up in his rocket for the first United States sub-orbital flight. That flight, and those of the other original seven astronauts, galvanized the thinking of an entire generation.

Space flight didn't turn us all into astronauts, but it helped us see the the world as a place of possibilities - not improbabilities. How many children in 1961 said to themselves - in that sort of wide eyed way that children do - the astronauts

succeeded, our country succeeded, I can succeed too. Mr. Chairman, I think there were probably quite a few.

So I very much want to see the Christopher Columbus Center built in Baltimore. It's not only going to provide highly skilled jobs, additional tax revenue, and valuable educational lessons for millions of people, it's going to be an educational beacon for the children of Baltimore - in fact for children everywhere.

Baltimore will be The City That Reads - in part because the young people of this region will know that learning to read and think is the first step toward being able to work in a place like the Center of Marine Biotechnology.

The oceans today are as big a mystery as outer space. And exploring the underseas has the potential of providing practical and cost effective products. So I very much hope that the federal government will become partners with the City of Baltimore and the State of Maryland in studying - and obtaining economic benefit from - the world's vast, and still mostly unknown - marine life.

As for the question that may be on some of your minds: 'But why Baltimore?' -- Let me just quickly run down the reasons.

- The Center for Marine Biotechnology is already located in

Baltimore. Some of the top scientists in the field - including Dr. Rita Colwell - are here, as are Johns Hopkins University and the University of Maryland - both of which have leading programs in biotechnology. (The Center of Marine Biotechnology, by the way, moved into offices in the Community College of Baltimore last month and the Center is already using all of its available space. So the building that we are proposing the federal government fund is needed and needed quickly.)

- Baltimore sits on the most important estuary in the United States. The quality and volume of marine life in the Chesapeake Bay are known worldwide. With the Christopher Columbus Center located here, the bay will be easy to study.
- The National Aquarium already attracts over a million visitors a year. The Christopher Columbus Center will provide these visitors with additional education and entertainment opportunities.
- Baltimore is close to Washington, D.C., the Department of the Navy, the National Institutes of Health, NOAA, and other government agencies dealing with marine sciences.
- The public officials and citizens of this region are united behind the Christopher Columbus Center. It is the ideal research facility for this area, and we intend to work very

hard to make sure that it benefits all of the people of the United States.

Mr. Chairman, again, I want to thank you for coming to Baltimore, and I look forward to the day in 1992 when this subcommittee comes back to Baltimore for the dedication and opening of the Center of Marine Biotechnology.

Thank you.

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Testimony of Mayor Kurt L. Schmoke Submitted
to the Subcommittee on Natural Resources,
Agriculture, Research and Environment

Mr. Chairman and Members of the Subcommittee:

Christopher Columbus sailed west, certain he'd find India. He didn't. Nevertheless, we easily forgive, and for the most part ignore, his errant navigation. Instead, the world is preparing to celebrate the 500th anniversary of Columbus' triumphant voyage. Why such universal admiration for a man who never found what he spent so much of his life looking for?

Because Columbus changed civilization, and he did it through exploration and daring. Columbus' desire for discovery, and his willingness to question old assumptions and look for new answers, are virtues that Americans resort to again and again to solve problems, save lives, and advance civilization.

So far from forgetting Columbus, we honor him - soon with a quinncentenary celebration. But the greatest honor we can pay Columbus is to not loose sight of the qualities that set him apart. Columbus said he was looking for India. But what he really set out to discover was knowledge - knowledge that could be used for the benefit of others.

The City of Baltimore and the State of Maryland want to do the same. That is why, together, they are investing \$117 million in the Christopher Columbus Center of Marine Research and Exploration, to be located at the Inner Harbor in the downtown Baltimore. The Center's home will be Baltimore, but its benefits will reach across the country and around the world.

The Christopher Columbus Center is actually a multi-building complex on four Inner Harbor piers. The Center will be part research, part public education and entertainment, and part history.

Already existing and open since 1981, is the National Aquarium in Baltimore. The National Aquarium has attracted more than 10 million visitors, including 1.45 million last year, 100,000 of whom were children. The Aquarium is operationally self-supporting, generates 5 million annually in local tax revenue, and has led to the creation of 3000 jobs.

The National Aquarium, with its 6,000 marine and fresh water animals also serves as an international repository of rare phenotypes, giving marine biologists the most complete genetic database in the world. And the National Aquarium will soon open a marine mammal pavilion for displaying beluga whales and bottlenosed dolphins. The pavilion will also house a library and research laboratories.

New to the Christopher Columbus Center will be a Maritime Museum and a Center of Marine Archeology - both of which will serve science and the public.

The Maritime Museum will showcase research in progress throughout the Christopher Columbus Center. This will enable visitors to learn about marine biotechnology and its practical applications.

The Center for Marine Archeology, which was jointly created by the Maryland Historical Trust and the National Oceanic and Atmospheric Administration, will locate, excavate, preserve and exhibit historic shipwrecks.

As with other parts of the Christopher Columbus Center, the benefits of the Center of Marine Archeology will extend far beyond Baltimore and Maryland. Archeological data will be used as a basis for studying climate changes in North America; and high technology robots will be developed for deep sea exploration.

The heart of the Christopher Columbus Center - and the only part for which federal assistance is being sought - is the Center of Marine Biotechnology (COMB).

There is nothing like COMB - or the Christopher Columbus Center, generally - anywhere in the world. (That does not mean,

however, that others have failed to recognize the economic importance of this field. On the contrary, both the Japanese Ministry of International Trade and Japanese business are already making a very large investment in marine biotechnology. (See below.)

The benefits of the Center of Marine Biotechnology to Baltimore and the country as a whole are numerous.

For Baltimore, the Center will assure our place as the premier location in the world for biotechnology research and development. It will enhance the scientific programs now being carried out by Johns Hopkins University and the University of Maryland, and will serve as an important source of both pure and applied research for the Johns Hopkins Bayview Research Campus, a biotechnology industrial park that is being developed by Johns Hopkins.

But COMB will do much more for Baltimore and its surrounding communities than simply tie into the work of two of this region's most prestigious academic institutions. For Baltimore and Maryland, COMB will provide jobs, many of which will be high-tech, high paying jobs. COMB will also provide non-technical employment and summer work for students. And the Center will add to Baltimore's already thriving tourist industry, make a significant contribution to our tax base, and raise the profile of education, scholarship and research at a

time when we are putting a major emphasis on, and increased financial resources into, public education and literacy.

Our goal is to make Baltimore the city that reads, and the Center for Marine Biotechnology, with its attributes of exploration, economic opportunity, and scholarship will give our young people the most eloquent explanation possible for why reading and learning are so important.

The Center for Marine Biotechnology will also give a demonstrable and much needed boost to the Baltimore economy. However, both the pure science and the practical applications derived from that science at the Center of Marine Biotechnology will serve the health, environmental, agricultural and defense needs of not just Baltimore, but the entire nation.

Comparisons can be made with genetic engineering. After 20 to 30 years of research, the practical benefits of genetic engineering, especially in medicine, are growing exponentially. And there has been a corresponding growth in the number of genetic engineering firms. Similar production and manufacturing spin-offs can be expected in marine biotechnology.

But it won't take 20 to 30 years for the link to be made between research conducted at the Center of Marine Biotechnology and industrial production.

Scientists at COMB (which is currently located at the Community College of Baltimore) and the University of Maryland have already developed a "super glue" from a marine bacterium, the kind that allow barnacles to stick so tenaciously to ship hulls. A newly formed biotechnology company is now producing the adhesive.

Barnacles and other encrusting marine life are actually a form of biofouling. Biofouling costs the nation \$1 billion annually, and is a particular burden for the Navy in that encrusting marine life on a ship greatly increases drag and reduces fuel efficiency. That is why the Navy has already awarded the Center of Marine Biotechnology a \$6.7 million grant to study the microbiology of marine organisms. The goal is to develop a nontoxic substance that can be put on ships to prevent marine life from attaching.

This research will also be important to our nation's utilities. Organisms attach to heat exchangers in nuclear and coal fired power plants reducing their efficiency. But again, by studying the basic ecology of these organisms, nontoxic materials can be produced that, when applied to the heat exchangers, will keep them clean of organisms.

Another area where the benefits of marine biotechnology will be felt well beyond Baltimore is in the cultivation of Chesapeake oysters. Oyster harvesting means jobs for Chesapeake

waterman, but they also mean a delicacy for seafood lovers everywhere.

The number of oysters caught in the Chesapeake has been dropping. But the Center of Marine Biotechnology is studying the life cycle of oysters. What they've discovered is that bacterium produce a "biofilm" on underwater surfaces. The bacterium, in effect, condition the rock surface and signal the oyster larve to attach to that surface and grow.

With the discovery of this new bacterium, researchers at COMB potentially have a way of getting oysters to produce more rapidly and with a higher probability of survival.

Replenishing oyster harvests is one form of "aquaculture," a sub-science of marine biotechnology designed to get fish and shellfish to grow faster and with fewer diseases. The potential benefits of aquaculture to a hungry world hardly need to be stated.

One scientist at the Center of Marine Biotechnology has already isolated the growth hormone in a fish, cloned it in bacterium and put it back into the fish to make the fish grow faster. This technology will allow fish producers to get their product to market faster, in larger quantities, and with a greater return on investment.

Perhaps the most important reason for the federal government to invest in the Center of Marine Biotechnology is marine pharmacology. The ability to isolate compounds in marine organisms holds out the promise of identifying new drugs to fight AIDS, cancer and other diseases.

This scientific field could also lead to the development of pharmacological compounds that will biodegrade toxic substances. The recent oil spill in Alaska, as well as industrial water pollution generally, demonstrates the importance of pursuing this technology.

In asking the federal government to contribute \$54.4 million for capital costs associated with the Center of Marine Biotechnology; specifically for the building, equipment and site improvement, Baltimore is looking for a partner, not a benefactor.

Both the City and the State recognize that they must shoulder the majority of the financial burden for the Christopher Columbus Center. We want the Center to be identified with the Baltimore-Washington region, and we want to take the primary responsibility for financing its construction and operation.

Baltimore's contribution to the Columbus Center includes the donation of 15 acres of land, valued at \$33 million, on

Piers 5 and 6 of the Inner Harbor. This land, the last parcels at the Inner Harbor, could have been sold to private developers, for millions of dollars. However, the City will receive no direct financial benefit from the property - choosing instead to have these piers used for education and the advancement of science.

In addition to Piers 5 and 6, Baltimore is contributing land on Pier 4; a 1000 car parking garage (still to be built); site improvements on Piers 5 and 6; grants to the Marine Manual Pavilion; and project management by Charles Center Inner Harbor Management. These additional capital costs are valued at \$38 million, making Baltimore City's total contribution \$71 million. (This does not include the Maritime Museum and the Conference Center which are being jointly funded by the City and the State).

Furthermore, the Columbus Center is also receiving private sector support. Private Foundations, corporations, and individuals are contributing almost \$20 million dollars toward the Marine Mammal Pavilion and Maritime Museum Exhibitions.

Why should the Federal government become involved in the Christopher Columbus Center? Some of the reasons have already been suggested. The Center - in particular the Center of Marine Biotechnology - is on the cutting edge of a type of research that holds out the hope of lessening or solving serious health

and environmental problems.

It is not unreasonable to expect the fruits of marine biotechnology to lead to the development of new drugs, safer and more abundant food supplies, cleaner water, new non-toxic substances, high technology underwater research equipment, organisms to control and clean up oil spills, and the development of products and materials needed for national security.

But there are other reasons for federal government to invest in the Christopher Columbus Center. Those reasons have to do with national pride and national leadership. The United States has been preeminent in science. Time and again we have demonstrated that we have the academic and industrial capacity to lead the world in high technology. But our competitors are gaining on us. We no longer have the luxury of delay. Failure to do the pure research today in marine biotechnology means we will not be prepared to manufacture, market and sell the derivative products of that research tomorrow.

We won't be ready, but the Japanese who have nearly cornered other important high technology markets, will.

The Japanese are constructing two biotechnology research centers - one in Shimizu City and the other in Kamaishi for a total investment of 6 billion yen (\$44 million). Why are the

Japanese making this large investment? Because - in the words of "Tradescop," a Japanese trade journal - "some estimates of the future size of the entire marine biotechnology products market run as high as two trillion yen annually." At today's exchange rate, two trillion yen is over \$149 million.

The Japanese have made a commitment to marine biotechnology. So have the people of Baltimore. I hope the federal government will do the same by offering its financial support and moral and economic leadership to an enterprise filled with as much mystery, and hope for the betterment of humanity, as our entry into space - and Christopher Columbus' westward voyage to the New World.

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Mr. McMILLEN. Thank you very much, Kurt.

I was interested in some of your comments earlier today, over at the groundbreaking for the light rail, when you were talking about the Japanese involvement, that they are spending \$44 million for two facilities. In the Baltimore Sun, I don't know if you saw this article on Saturday, they pointed out a \$468 million capital construction plan by the Japanese for two similar centers based in Japan. Whatever the number, I mean, it is a significant investment.

The point of this center is that it will enable the United States to maintain its lead and also to ensure that that lead holds, at least for 3 to 5 years.

Mayor SCHMOKE. It is a competitive issue. International competition is involved, in terms of research and development, in terms of a new field of science, and I think that we are poised with the opportunity to move ahead and to show not only that we have been leaders but that we can continue to be leaders in the future.

Mr. McMILLEN. Mr. Chairman?

Mr. SCHEUER. Well, Mayor Schmoke, I want to tell you how much I enjoyed being here with you. I have appeared with you in Washington. I heard you testify. You are truly one of the most intelligent and courageous voices in our Nation on subjects other than marine biology, and I salute you for the marvelous leadership you are showing in this city and for continuing the momentum for this great center.

Now it is perfectly transparent and obvious what this center can do for the City of Baltimore. It is obvious, the education benefits and so forth, to the kids who are going to be involved systematically and pervasively, but as a national Congressman I have to ask, what is it going to do for the country? What will this center here in Baltimore offer to the United States?

Mayor SCHMOKE. Well, I think a number of things, Congressman, not only because of our proximity to Washington, D.C., the seat of the Government, but because of our proximity to all the agencies involved in marine research. We will be able to draw upon their talents and they upon ours. The Navy, for example, is already interested in some of the early research being done here at this Center of Marine Biotechnology dealing with the biofouling issue, making sure that we can clean the barnacles that are a tremendous drag on the hulls of some of our naval ships. That is a defense-oriented issue, but when we look at the other products, such as the ability to develop these microorganisms to clean up our rivers and streams all over the world, dealing with oil spills such as you mentioned before in Alaska, it offers an opportunity for research and development that will be used for everyone in the country.

I guess to a certain extent I was going back in my mind just quickly to the space analogy. Someone said, "Well, you have to blast off to space somewhere." We chose to be at Cape Canaveral. This, as far as marine biotechnology, this is the Cape Canaveral of marine biotechnology. This is the site, the location from which all this research will take off. It will then benefit everybody, not only in this country but around the world.

Mr. SCHEUER. And I take it you are plugged into NOAA, the National Atmospheric and Oceanic Administration?

Mayor SCHMOKE. Yes, we are.

Mr. SCHEUER. And the U.S. Fish and Wildlife Service in the Interior Department?

Mayor SCHMOKE. All of the Federal agencies involved with marine research have taken a look at this and in one way or another are interested in it. Clearly everyone is interested in making sure that we have a partnership, that is not just their budget that is going to be involved in this, but it is this partnership of the city, State, the Federal Government and the private sector. We have tremendous involvement from the private sector. If that remains, and I know that it will, all of those agencies will participate and will benefit.

Mr. SCHEUER. Well, describe how the private sector fits in, and how they can turn a profit and perform a service to Baltimore and to the country.

Mayor SCHMOKE. Well, I know that the Governor mentioned Mr. Harrison a couple of times. He will be very interested in this, certainly. That is just one tourism aspect, but we think that there are a number of products that will actually be developed through this research, and they will in fact be marketed, and whole new industries will grow up around marine biotechnology. We have already seen it developing, and we think that it will explode over the next few years.

Mr. SCHEUER. Well, you are truly making this into a national facility. It happens to be located here, but with all kinds of national promise.

Mayor SCHMOKE. We think so. We think it really will be of great benefit to the entire Nation.

Mr. SCHEUER. We will be very excited in watching it grow.

Mayor SCHMOKE. Thank you.

Mr. McMILLEN. Kweisi?

Mr. MFUME. Mr. Mayor, thank you very much for being here today. Let it not be lost on the record that when you last came before the committee, that Jim Scheuer was one of your strongest advocates, and talked to some of us after your testimony about why we ought to be advocates.

Mr. McMILLEN. I think he was the only advocate.

Mayor SCHMOKE. That was a long day, Congressman, and I think he was the only advocate.

Mr. MFUME. Well, we are glad to have you back.

Let me just say while you are here, I think it is important to let the record also reflect that I consider you to be a futurist in the area of science and education, and that is not an easy thing to do. It is easier, I think, to be consumed as a mayor in the day-to-day necessities of running a city, those things that have to get done. It is much harder as a mayor to be daring and forward-looking. You display that and you do it in such a way that you have balance between the two, and I am sure that the people of this city appreciate it. I know myself and the other members of this congressional delegation talk about that quite often, and we thank you for it.

It is fair to assume that our generation, Mr. Mayor, before the end of our lives, if this project takes off, it will be beneficial in

some way. We will find ourselves benefitting, that it has arrived and found new life in Baltimore, but the greatest beneficiaries—and this goes back to the chairman's statement—I think will be the Nation and countless generations of young people who will grow up not only in a city that reads but in a Nation that caught a glimpse of the future and moved ahead on a project in a bold and daring new area that really in fact did make a difference.

Mr. Mayor, your administration has been quite sensitive to the concerns of Members of Congress on this. Whenever we wanted information, you have gotten it to us. Whenever we needed someone to be available, they were there. I would like to ask you, if I might, as you sit and you think about this tremendous opportunity that is unfolding here, and what it means for this city now and long after all of us are gone, have you considered—as you have in a number of other projects, in a way that you uniquely go about doing this—a way to involve the masses of Baltimoreans who perhaps may not understand the significance of this, who in other events and other projects have found a way to participate?

I don't know whether or not you have thought about that, if your staff has given you some ideas. I know that the success of projects depends to a large extent not only on the appropriations but on the degree of excitement that the citizens have about it.

Mayor SCHMOKE. Absolutely, and I appreciate that. One of the things, as you know, Congressman, the graduating class of 2000 entered first grade this past September, and we started with that group, provided them with some materials to get them thinking already about the next century. As a part of the Columbus 500 activity, we are going to have a wide range of problems involving students and their parents and the citizenry in general.

While the Governor was testifying, I don't know if you saw the ship that sailed by here, but we have had the Lady Maryland and a number of students who are out there learning about the Bay, learning about maritime life, getting more and more interested in this entire area of marine life, so we are starting right now to get them interested. We hope that with a positive sign from Congress that they indeed will participate with us, that that will show a new partnership, a sign of vision and hope, and let people know that in Baltimore the best is yet to come, that we are poised on an era of great hope, great prospects.

In doing that, all of those things together, yes, we will involve the entire community in this project. The 1992 celebration, we have already thought about that as a focal point. There we are looking at projects that are inclusive of the entire community and not exclusive.

Mr. MFUME. Thank you, Mr. Chairman.

Mr. McMILLEN. Ben?

Mr. CARDIN. Well, I just would like to associate myself with the comments of Congressman Mfume and congratulate you on the leadership here in Baltimore. I do think that your administration is clearly investing in the future with your commitment towards education, which is so important to the future of this country, and your commitment towards the environment.

Now let me ask, if I might, just one specific question. That is, the piers that are being talked about as part of the Columbus Center,

you mentioned that they are perhaps the most valuable pieces of real estate that we have left in Baltimore. Perhaps you just could comment as to what other tempting offers could be made for the use of that. I mean, obviously it is a major contribution that is being made by a government here to make those piers available. Maybe just for the record you could tell us some of the desires—

Mayor SCHMOKE. Well, just about every week we have had tremendous proposals presented to us for that land, whether it is offices, condominiums, some mix. They look at that as one of the most valuable pieces of real estate, not only in Maryland but in this country, in terms of a piece of land that can be marketed. We have given a conservative value in the booklet that has been presented, but we think that the contribution of land, that area, will exceed \$33 million. That is a significant investment by a community, to forego that type of development in order to have this, which I think in the long run is going to mean more to our community and to the country than if we did an office building or some other type of use.

Mr. CARDIN. Thank you.

Mr. McMILLEN. Thank you once again.

Let me just add that in your testimony you also talked about the potential for marine biotechnology in products. You mentioned that the estimate was somewhere in the neighborhood of \$150 million. I just returned from Japan a couple of weeks ago, and talked with a number of officials who have pinpointed this area as one of the areas they are going to focus on. I would just like to reiterate what you already discussed in your testimony. That \$150 million is direct products. That does not include the \$1 billion in biofouling and the like that you addressed in your testimony. I think that is a very important point when we talk about this international competitiveness issue.

Again, thank you very much, and we congratulate you.

Mayor SCHMOKE. Thank you, and thank you again, Mr. Chairman.

Mr. SCHEUER. Good to be here.

[Applause.]

Mr. McMILLEN. Our fourth panel is comprised of John J. Carey, the Deputy Assistant Administrator of the National Oceanic and Atmospheric Administration; Dr. Michael Hooker, president of the University of Maryland-Baltimore County and, I might add, one of the leading experts on biotechnology in this country and a tremendous advocate for the growth of the industry in this State; Dr. Frank Perkins, dean and director of the Virginia Institute of Marine Sciences at the College of William and Mary; and Dr. Fred Singleton, the executive director of the Center of Marine Biotechnology at the University of Maryland here. Thank you all for coming.

Dr. Perkins is not here yet. Well, why don't we begin, if you would summarize your testimony for time's sake, and then we will be sure to include the whole of your testimony in the record. Mr. Carey, do you want to begin?

STATEMENT OF MR. JOHN J. CAREY, DEPUTY ASSISTANT ADMINISTRATOR FOR OCEAN SERVICES AND COASTAL ZONE MANAGEMENT, NATIONAL OCEAN SERVICE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Mr. CAREY. Thank you, Mr. Chairman. Chairman Scheuer and members of the subcommittee, it is indeed a pleasure to appear before you today and to be here in Baltimore, in this magnificent national aquarium. As an adopted Marylander, I am justifiably proud of the tremendous progress that has been made in the State of Maryland and, particularly, in Baltimore, to enhance our use and understanding of the marine environment.

Mr. Chairman, I would like to have my detailed statement, which does go through many of the programs and activities of the National Oceanic and Atmospheric Administration with respect to the wise use and conservation of the Chesapeake Bay, inserted into the record.

Mr. McMILLEN. Without objection, so ordered.

Mr. CAREY. Thank you, Mr. Chairman.

NOAA has long been involved in programs of research, information, and management involving the Chesapeake Bay. We have had a good, strong working relationship and partnership with the State of Maryland and with the other States in the Bay region. The proposed establishment of the Christopher Columbus Center for Marine Research and Exploration by the State of Maryland and the City of Baltimore provides an excellent opportunity to build on that foundation and forge a new partnership at the local, State, and Federal levels.

NOAA supports the establishment of the center. Its focus on the development of the resources of the sea, enhancing the richness and abundance of fishery stocks, preserving and studying historical shipwrecks, and using marine science technology to advance underwater archaeology, all enhance NOAA's present activities. Once established, NOAA would consider providing technical support to the center's program, co-locating NOAA activities and operations with the center, and supporting and using the center's facilities for the conduct of important research that would further the missions of NOAA.

I am pleased to report to the subcommittee that NOAA is already directly involved in the center. Through a cooperative agreement, NOAA and Maryland are engaged in establishing a National Center for Maritime Preservation Technology which is planned to be housed at the Christopher Columbus Center of Marine Archaeology. As the committee is aware, NOAA is authorized to designate national marine sanctuaries for the purpose of conserving and managing historic and cultural resources such as submerged historical shipwrecks, and the national center will develop new technologies in marine archaeology and apply existing technologies and marine science that will improve the management of such resources.

NOAA efforts are underway in the area of aquaculture and biotechnology through Maryland and Virginia Sea Grant programs. Of direct importance to aquaculture interests are oyster disease research leading to improved oyster strains and management that

could help revitalize oyster production along the Atlantic Coast. As part of our program of research in marine biotechnology, NOAA's Sea Grant program is supporting fundamental studies in genetic engineering of aquatic species. NOAA is also studying the process of oxygen depletion in the overenriched bottom waters of the Chesapeake Bay.

We are working cooperatively with the Army Corps of Engineers in the Chesapeake Bay and elsewhere to study the use of dredged materials for creation of wetlands and submerged aquatic vegetation habitats, and NOAA is continuing to work cooperatively with the U.S. Fish and Wildlife Service and the States of Maryland and Virginia on the emergency striped bass study.

In 1988 we expanded our status and trends program in the Chesapeake Bay and in its tributaries. Our Chesapeake Bay Environmental Data Directory was published in 1987, again in collaboration with the Maryland and Virginia Sea Grant college program, and it contains descriptions of the environmental data collected throughout the Chesapeake Bay. This spring, NOAA will initiate a pilot CoastWatch project for the Chesapeake Bay, working in cooperation with the Chesapeake Bay Institute of the Johns Hopkins University and the Virginia Institute of Marine Sciences of the College of William and Mary. This project is focused on improving estimates of the algal blooms throughout the Bay that are thought to be linked to the oxygen depletion problem.

We see very direct linkages between these activities that are going on within NOAA and the type and kind of research that is being conducted at the universities in this area and the research that would be conducted at the proposed center. The science and biomedical research planned for the center's Marine Mammal Pavilion, for example, which has not been mentioned here today, will also assist NOAA in developing baseline information and measuring contaminant levels in marine mammals, which then can assist us in developing rehabilitation programs for stranded mammals. The education component that Mayor Schmoke talked about can further NOAA's efforts in informing the public of conservation and protection programs in the marine environment, and particularly with respect to marine mammals.

Mr. Chairman, I have only been able to touch the surface, only provide and cite a few examples of the breadth of activity that is going on in NOAA with the cooperation of the involved States and institutions, and, particularly, the State of Maryland. We see the proposed Christopher Columbus Center as the next logical step in the evolution of the concern for the proper development of the rich marine resources of this area, and a needed focal point for promoting our national interests in marine biotechnology research.

I thank you for being able to appear today. In closing, I want to extend our support to work closely with you, the State, and the City of Baltimore in seeing this bold vision for the future become a reality. Thank you, Mr. Chairman.

[The prepared statement of Mr. Carey follows:]

Testimony
of
John J. Carey
Deputy Assistant Administrator for
Ocean Services and Coastal Zone Management
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

before the
Subcommittee on Natural Resources, Agricultural
Research, and Environment
Committee on Science, Space and Technology
U.S. House of Representatives

May 15, 1989

Mr. Chairman and Members of the Subcommittee:

I thank you for the opportunity to testify on behalf of the
National Oceanic and Atmospheric Administration (NOAA), U.S.
Department of Commerce.

NOAA is the Nation's lead marine science agency, which is
charged with providing information, research, and management
services for the Nation's ocean, coastal, and estuarine
resources. With 25 coastal and marine research facilities, 7
National Marine Sanctuaries, 29 State coastal management
programs, 17 National Estuarine Research Reserves, and direct
ties to 29 universities and colleges through its National Sea
Grant College Program, NOAA is uniquely suited to address not
only broad scale coastal ocean issues, but also specific issues
affecting individual estuarine systems along the U.S. coastline
such as the Chesapeake Bay.

NOAA's programs cover a broad range of activities that directly and indirectly relate to future application of aquaculture and marine biotechnology to the Nation's oceans and estuaries. Our Sea Grant activities are heavily involved in aquaculture and biotechnology research. Our fisheries management and habitat conservation programs support our basic understanding of coastal marine species and ecosystems. NOAA's environmental monitoring and assessment efforts are sentinels for understanding biological tolerance and toxicity and protecting living marine resources. In addition, our responsibilities for coastal zone management provide a unique perspective toward a cooperative State/Federal partnership in coastal resource use and protection.

NOAA supports the establishment of the Christopher Columbus Center for Marine Research and Exploration by the State of Maryland and the City of Baltimore, but does not support direct Federal funding for the construction or operation of the facility. However, were such a facility established, NOAA would consider providing technical support to the Center's program, co-locating certain NOAA operations with the Center, if that proves advantageous. NOAA also would consider using the Center's facilities for NOAA-sponsored research and/or supporting Center research programs that are consistent with NOAA's mission and research plans. This is an excellent opportunity to forge a partnership between local, State and Federal government. The Center focuses on developing the resources of the sea, enhancing richness of species and abundance of stocks, preserving and

studying historical shipwrecks, and using marine science technology to advance underwater archeology. All of these objectives enhance NOAA's present activities.

I will now highlight some of NOAA's efforts in the Chesapeake Bay which address the application of research and technology for the wise use and conservation of the Bay's resources and the ways NOAA programs complement the proposed research and exploration center.

It pleases me to report that NOAA is already directly involved in the Center. Through a cooperative agreement, NOAA and Maryland jointly established the National Center for Maritime Preservation Technology, which is planned to be housed at the Christopher Columbus Center of Marine Archeology. NOAA is Congressionally authorized to designate national marine sanctuaries for the purpose of conserving and managing historical and cultural resources, such as, submerged historical shipwrecks. The National Center will develop new techniques in marine archeology and apply existing technologies in marine science that will improve the management of such resources. A Chesapeake Bay tributary will serve as test site for the National Center; the end result being a model program in marine historical and cultural resource protection other States can emulate and a significant step by the Federal government to enhance the value of marine cultural resources to the Nation.

NOAA efforts are underway in the areas of aquaculture and biotechnology through the Maryland and Virginia Sea Grant programs. The Sea Grant research program on the Chesapeake is directed to help Bay users whose livelihoods are dependent upon its resources and to discover new scientific knowledge about the Bay itself. Oceanographic studies of the recruitment of the blue crab resource in the Bay have served as a model for other estuaries. Of direct importance to aquaculture interests, our oyster disease research is leading to improved oyster strains and management that could help revitalize oyster production on the Atlantic Coast. In a similar vein, research on the nutritional and environmental requirements of striped bass could help restore this popular sportfish and important food fish.

The National Marine Fisheries Service (NMFS) also works cooperatively with Maryland and Virginia scientists at the Oxford Cooperative Laboratory, Oxford, Maryland, to improve our understanding of the oyster diseases MSX and Dermo.

As part of its program of research in marine biotechnology, NOAA's Sea Grant Program is supporting fundamental studies in genetic engineering of aquatic species. The goal is to develop genetic techniques for inserting additional genes in marine animals to give them desirable characteristics such as rapid growth. This could result not only in species revitalization, but in improved aquaculture production of desirable species. Sea Grant researchers in lab experiments are using protein chemistry

and genetic engineering technology to manipulate genes in species like striped bass and white perch to make them easier to domesticate and produce.

Sea Grant research, which is addressing the major environmental and ecological problems in the Bay, has led to a better understanding of the processes that are impacting the Bay. For example, oxygen depletion has been identified both as an indicator of reduced environmental quality and as a threat to the Bay's living resources. NOAA, through the Maryland and Virginia Sea Grant programs, is studying the processes of hypoxia and anoxia - the loss of life-sustaining oxygen, especially in the over-enriched bottom waters. By bringing together scientists from a number of different fields, this research is the first major attempt to develop a comprehensive picture of the related physical, microbiological and chemical processes that produce these effects. This program, initiated in 1985, has greatly refined the scientific understanding of complex relationships among nutrients, production of organic material, cycling of carbon, oxygen demand and the conditions of oxygen depletion in the Bay.

Sea Grant's marine advisory and extension programs in Maryland and Virginia have specialists located along the Bay shoreline to serve the needs of public in aquaculture, commercial and recreational fisheries, and seafood processing. In addition, marine education programs are in place to bring the message of

the importance of the Bay to the students of the Chesapeake Bay region. NOAA, through its system of fisheries research and environmental research centers, supports investigations on coastal wetland ecology and means to avoid and mitigate wetland loss.

NOAA works cooperatively with the Army Corps of Engineers in the Chesapeake Bay and elsewhere to study the use of dredged materials for creation of wetlands and submerged aquatic vegetation habitats. To prevent or reduce damage to fishery resources and their habitats, NOAA works closely with State and other Federal agencies to evaluate applications for Federal permits for disposal of dredged materials and waste discharges into waters of the United States. NOAA was involved in the development of the Chesapeake Bay Wetlands Policy, adopted by the Chesapeake Executive Council in January 1989. This policy calls for a net gain of tidal and nontidal wetlands in the Bay watershed.

NOAA continues to work cooperatively with the U.S. Fish and Wildlife Service and the States of Maryland and Virginia on the Emergency Striped Bass Study. In addition to research on possible causes of high mortality of juvenile striped bass, NOAA is supporting the States' striped bass tagging efforts. In 1987, Maryland and Virginia tagged 4,000 and 5,000 striped bass, respectively, in the Bay and its tributaries. A summary of these

striped bass activities are included in a recent report to Congress entitled, Emergency Striped Bass Research Study, Report for 1987.

NOAA's environmental monitoring and assessment programs can contribute to and benefit from the technological programs of the proposed Center. The National Status and Trends (NS&T) Program, initiated by NOAA in 1984, describes the current status and future trends of selected contaminants in sediments, fish, and shellfish at approximately 150 sites nationally. A major product of the NS&T Program will be a national data base to aid in assessing trends of pollutant levels and their effects on living resources. The Program has two major components: the Benthic Surveillance and Mussel Watch Projects. Sediments and demersal finfish are sampled annually as part of the Benthic Surveillance Project. At Mussel Watch sites, oysters and sediments are also analyzed once each year for toxicants. In 1988, NOAA doubled the number of Mussel Watch sites in Chesapeake Bay and its tributaries.

NOAA assesses natural resource damage caused by releases of hazardous substances and oil discharges under Superfund and Clean Water Act legislation, respectively. NOAA's Hazardous Materials Response Program provides technical support to EPA and represents NOAA's natural resource trusteeship responsibilities. In addition, NOAA and EPA provide technical support to the Coast Guard in oil and hazardous substance spill response efforts.

NOAA sent a scientific support specialist to the scene of a leaking fuel barge in Chesapeake Bay in the summer of 1988 to assess the potential damage and coordinate response activities with the Coast Guard.

NOAA also provides Strategic Assessments of existing and projected estuarine and marine resource demands in terms of levels of use, resource availability, pollution discharges, potential environmental impacts, and use conflicts, and maintains comprehensive national inventories of estuarine and marine resources and their existing and proposed uses. The National Coastal Pollution Discharge Inventory contains information on coastal pollution loads.

NOAA maintains national data centers for archiving and retrieving oceanographic, hydrographic, and meteorological data. The National Oceanographic Data Center, working very closely with the Chesapeake Bay Program Computer Center, is assisting development of the EPA Chesapeake Bay Program environmental data base. The report, Chesapeake Bay Environmental Data Directory, was published in 1987 in collaboration with the Maryland and Virginia Sea Grant College Programs. It contains descriptions of environmental data collected throughout the Chesapeake Bay and where one can obtain the data.

NOAA recently developed a program called CoastWatch, in which near real-time data from NOAA's environmental satellites and other observations are applied to address coastal management

needs. Weekly summaries of sea surface temperature, wind drift, and other information are made available to scientists and local and Federal agencies concerned about outbreaks of red tide along the Southeast Coast. This environmental monitoring and information transfer will enable NOAA to provide warnings of future red tide occurrences.

This spring, NOAA initiated a pilot CoastWatch project for the Chesapeake Bay, working with the Chesapeake Bay Institute of the Johns Hopkins University and the Virginia Institute of Marine Science of the College of William and Mary. This project is focused on improving estimates of spring algal biomass, thought to be linked to the Bay's oxygen depletion problems. An annual Bay CoastWatch program will help monitor how the Bay responds to major reductions in nutrient loads, planned over the next decade by Bay States and EPA.

Over a decade of NOAA experience in coastal resource management, under the authority of the Coastal Zone Management Act, has resulted in significant coastal resource protection at the State level. A prime example is the Chesapeake Bay. The Chesapeake Bay Commission is a direct outgrowth of the Maryland Coastal Zone Management program. These two efforts have been instrumental in promoting a proper balance between resource protection and use. The States of Virginia, Maryland, and Pennsylvania have utilized the coastal management program to improve the management of living marine resources in the

Chesapeake Bay through individual and interstate efforts. These three States also have initiated, funded, and coordinated various research projects directly related to improving the health of Chesapeake Bay waters.

An interagency agreement has been developed between EPA and NOAA to ensure that NOAA-approved State Coastal Zone Management Plans and the EPA-approved Comprehensive Conservation and Management Plans under development through EPA's National Estuary Program are complementary and not duplicative. NOAA and EPA have an interagency Memorandum of Understanding for the Chesapeake Bay Program, in which NOAA is an active partner in the Federal/State cleanup effort.

NOAA also administers the National Estuarine Research Reserve System. The goal of this program is to establish and manage a national system of reserves representing different estuarine areas throughout the United States. The reserves serve as field laboratories in which studies are conducted on natural and human processes occurring within the estuaries.

In Maryland one reserve (Monie Bay) site has been designated on the eastern shore which encompasses over 3,000 acres of tidal creeks, salt marshes and submerged aquatic vegetation beds. Two additional sites have been nominated by the State which will represent the Maryland western shore and upper bay waters. In

Virginia, four sites located on Mobjack Bay and along the York River are being considered for inclusion in the estuarine reserve research program.

The science and biochemical research planned for the Center's marine mammal pavillion will assist NOAA in developing baseline information and measuring contaminant levels in marine mammals. It can also assist in developing rehabilitation programs for stranded mammals. The education component can further NOAA's efforts in informing the public of conservation and protection programs for marine mammals.

Mr Chairman, that concludes my testimony and I welcome any questions that the Committee might have.

Mr. McMILLEN. Thank you.
Dr. Hooker?

**STATEMENT OF DR. MICHAEL HOOKER, PRESIDENT, UNIVERSITY
OF MARYLAND-BALTIMORE COUNTY**

Mr. HOOKER. Congressman McMillen, Congressman Mfume, Mr. Chairman, thank you for the opportunity to talk to you today. You have a copy of my written testimony which I would request be inserted into the record.

Mr. McMILLEN. Without objection, so ordered.

Mr. HOOKER. Let me in summary just address two questions that have already been asked, one by Congressman McMillen—"Why Baltimore?"—and the other by Chairman Scheuer—"What does the rest of the Nation get out of it?"

You have heard a number of reasons why Baltimore and why this location in Baltimore. An additional reason you are sitting in. It is the National Aquarium which, through the development of its Marine Mammal Pavilion next door and through the equipment that is already available, will be able to supply important technological services to the Center of Marine Biotechnology which otherwise would have to be constructed at considerable expense. I have in mind their water treatment facilities, holding tanks, test tanks, and also various testing devices and testing opportunities for many of the products that will be developed in the Center of Marine Biotechnology.

Now let me just say what the rest of the Nation gets out of it. Congressman McMillen has pointed to the editorial in the Sun that indicated that the Japanese Ministry of International Trade and Industry was committed to spending between \$400 and \$500 million in developing several marine biotechnology centers in Japan. Why are they willing to spend that much money? They are willing to spend that much money because they have estimated that the worldwide market at the turn of the century for biotechnology products will be \$15.4 billion annually.

Now I think that is an inflated figure, but even if it is inflated by 100 percent, it is still a phenomenal, a phenomenal market for biotechnology products. The question is, who is going to tap that world market? What we have the opportunity to do here with the Maryland Biotechnology Institute's Center of Marine Biotechnology is to assure that the United States will be a major player in that biotechnology ball game.

The resources are in place already. The Mayor indicated that this is one of the few research centers in the country that has to turn away research grants because we simply don't have the space and we don't have the equipment to service the grants. Mr. Chairman, you asked earlier about the participation of the private sector. The private sector is standing in line to fund the projects of the Center of Marine Biotechnology, but again, the projects can't be carried forward at this time because there simply isn't the space and there isn't the equipment to do so.

Let me just briefly enumerate and summarize from my testimony some of the products that we can expect to find. The most important fact to recognize about marine biotechnology and its poten-

tial is that since the beginning of life on this planet, organisms have been evolving in marine environments, marine environments that are very different from terrestrial environments, and so the organisms understandably are very different from terrestrial organisms. There are approximately 1 million species of marine animals, and very few of those species have been studied thoroughly for enzymes, the proteins that they produce that may be of benefit to humankind.

One of the reasons that we have not thoroughly assayed those species to determine the proteins that they produce, is that we had no way of producing them in a terrestrial environment. Well, genetic engineering now gives us that capacity. We can mine the depths of the oceans, very hostile environments at hyperbaric pressures, at very low temperatures—or very high temperatures in the thermal vents in the ocean—we can determine the organisms that are there, we can study the enzymes that those organisms produce. When we find enzymes that are valuable, for example, as anticancer agents, as we know some of them are, we can identify the genes that control the synthesis of those enzymes, take those genes out of the marine organisms, put them in a common terrestrial organism, and then grow them up in fermentation vats and produce a new pharmaceutical industry.

We will be able to do the same thing, for example, in service to the chemical industry, in identifying catalysts, enzymes that promote chemical reactions at very low temperatures. Some of these organisms live out their lives in environments that are approximately 4 degrees centigrade temperature, and they are engaged in metabolism at those temperatures, which is a very low temperature. Presumably the chemical reactions taking place are catalyzed in order to take place at very low temperatures.

One of the things about the chemical industry is that chemicals are fairly expensive because it is energy-intensive to produce them. Typically it is energy-intensive because a great deal of heat has to go into cracking petroleum, for example. If we could synthesize chemical compounds at very low temperatures, using the catalytic agents that we will identify for marine organisms, then we could cut by significant orders of magnitude the costs of production of chemicals.

Again, you can begin to get a glimmering of why MITI thinks that the world market for these biotechnology products is going to be so great. The marine glue was already mentioned. The advantage to aquaculture was mentioned. Let me just say what it is about aquaculture that marine biotechnology can serve so well, because we have been growing fish on land in tanks for a long time. The reason the aquaculture industry hasn't taken off heretofore is that it is very labor-intensive and equipment/capital-intensive to grow fish on land. Fish don't normally accommodate to land, so we have to build tanks for them and we have to wait until they grow as nature dictates. If we could identify—

Mr. SCHEUER. Excuse me. Excuse me. We don't have to wait for them to grow as nature dictates. The Israelis are doing experiments right now in shortening the 24-hour daylight cycle to 12 hours, and altering the heat and the cold to shorten the seasons of the year from a 12-month year to a 6-month year, so that actually

they will adjust their new spawning patterns to a 12-hour day and a 6-month year and double or treble their productivity.

Mr. HOOKER. Thank you, sir, for pointing that out. The Center for Marine Biotechnology is cooperating with Technion and with the Biotech Institute in the Negev to clone genes that will promote the growth of these animals more quickly.

Mr. SCHEUER. Exactly.

Mr. HOOKER. Finally, let me just say that there is an important element of the Center of Marine Biotechnology and the Christopher Columbus Center that had not received a great deal of attention before Mr. Carey pointed it out, and that is the Center for Underwater Archaeology. Maryland is blessed to have a visionary, Rodney Little, who is head of the Maryland Historic Trust, who understands the importance of marine archaeology to the Nation and to our cultural life, and has married marine archaeology to the concept of biotechnology in the Christopher Columbus Center and proposes a major program in the development of technologies associated with marine archaeology.

One of the things that the University of Maryland will do is to work with the industry in this area, particularly Martin Marietta and Westinghouse, to develop underwater robotics for discovering and bringing up our underwater archaeological treasures. The same technologies, the same robotics, remote control vehicle technologies that are useful in underwater archaeology will also be useful in mining the oceans for marine organisms and for marine minerals.

Thank you very much, sir.

[The prepared statement of Dr. Hooker follows:]



THE UNIVERSITY OF MARYLAND

BALTIMORE COUNTY CAMPUS
Office of the President

Statement

by

Michael Hooker, President
University of Maryland Baltimore County
before the
Subcommittee on Natural Resources,
Agriculture Research, and Environment
Committee on Science, Space and Technology
U.S. House of Representatives

May 15, 1989

Ladies and Gentlemen of the Committee:

I am grateful for the opportunity to speak to you on behalf of the Christopher Columbus Center of Marine Research and Exploration. There are few projects I can imagine that represent a greater potential service to the national interest in building an economic base for our future.

You have heard that the Japanese have made a major investment in marine biotechnology and supporting maritime technologies. While I don't think U.S. policy should always be guided by what the Japanese are doing, I think in this instance they have shown a great deal of prescience. Let me say why.

U.M.M.

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Since the beginning of life on this planet, life has evolved in water. While humans have interacted with marine animals since the beginning of human civilization, marine organisms have not been the focus of the degree of scientific attention that has been received by terrestrial animals. There is a simple reason for this: the oceans offer an inhospitable research environment for us. For example, for a long time we have known that there were animals that had evolved to survive and thrive in the depths of the ocean where their physiology and biochemistry would have to be very different from that of terrestrial animals. It has been reasonable to conjecture that many enzymes and other proteins crucial to the life cycle of these organisms may have significant benefit to human life and technology, but it has been infeasible to contemplate mining the ocean depths for these organisms. The technology did not exist for enabling such organisms to be grown at surface temperatures and pressures. Now with the coming of age of biotechnology, we will be able to assay the organisms of the ocean depths to discover useful proteins and, after identifying the genes responsible for the synthesis of those proteins, we will be able to insert those genes into terrestrial organisms so that we may produce the desired substances. This is one good example of why we should be focusing on marine biotechnology at this time. It offers the promise of benefits simply not available to us from research directed only at terrestrial organisms.

The potential benefit of marine organisms to human health care is enormous. There are approximately one million marine species

of life, and very few have been examined to determine the potential of proteins that they produce for use in human health care. It is reasonable to believe that there will be found thousands of enzymes not produced by terrestrial organisms that can be used as anti-cancer therapeutics, psychotropics, anti-hypertensives, etc. The pharmaceutical industry is shifting from a chemical basis for manufacture to the production of diagnostic and therapeutics with the use of animal organisms. The pharmaceutical industry will be revolutionized by the production of biological pharmaceuticals, and it is crucial for the protection of the American pharmaceutical industry that we assay marine organisms for useful proteins.

In addition to the pharmaceutical industry, it is likely that numerous other industries will be fundamentally affected by marine biotechnology. For example, pollution detection technology should be considerably enhanced by a study of the mechanisms that enable fish and other marine organisms in the darkness of the ocean depths to detect their food through a greatly enhanced olfactory sense. Eels, for example, are capable of detecting substances in solution in the water as weak as a few parts per million. Understanding the mechanism of detection in eels should enable us to produce pollution detection devices, possibly biologically based, of similar sensitivity. This should help in the detection of toxic substances which can be lethal in exceedingly low levels of concentration.

I'm sure the committee is familiar with research that has led to the development of marine organisms that can consume an oil

slick and then self-destruct when their food source has been exhausted. Unfortunately, the research necessary to produce high efficient organisms and to prove their safety has not advanced sufficiently far to enable us to address the Valdez catastrophe. However, in a few years marine biotechnology should have produced a whole catalog of organisms capable of cleaning up environmentally destructive toxic spills.

The chemical industry will be enormously affected by the coming of age of biotechnology as we discover biological based methods of the production of chemical compounds that are now produced with more energy intensive technology. We know that chemical reactions take place in organisms that live in the ocean depths where the water is extremely cold (about 4° C.). Their highly sophisticated chemical reactions take place using catalytic enzymes that should be useful to the chemical industry. If existing chemical processes can be performed with much less heat than they now are, it obviously will be possible to save a great deal of energy, and hence cost, in the production of chemicals. Once low temperature catalytic enzymes are identified in marine organisms, those enzymes can be produced by gene transfer from marine organisms to terrestrial organisms.

Two potential uses of marine organisms are particularly appealing. One, which is already well under way at the University of Maryland Center for Marine Biotechnology, is to identify and produce commercially the protein glue that barnacles use to adhere to the bottoms of boats. Such glue is not water soluble, does not

require heat for bonding, remains effective through a wide range of temperatures, and has a very long useful life. It should have numerous industrial uses. Another particularly intriguing direction of marine biotechnology research is in the mechanism that enables migratory fish to travel hundreds of miles to spawn where they were born. Such navigation is probably made possible by exceedingly sensitive magnetic detection mechanisms, which should have potential use in terrestrial, marine, and space navigation.

Of particular interest to Maryland is the development of a biotechnology-based aquaculture. It should be possible through cloning of appropriate proteins to produce fish that grow to maturity in a fraction of the time that fish presently do and that grow considerably larger than fish that have not be genetically engineered for superior growth. Perhaps even more important to the development of an aquaculture industry, will be the possibility of developing vaccinations to prevent disease which now destroy a large percentage of fish produced through aquaculture.

The State of Maryland is uniquely situated to lead the nation in biotechnology research. There is an enormous concentration of molecular biologists already here, especially at the National Institutes of Health, The Johns Hopkins University, and the University of Maryland. The Maryland Biotechnology Institute, of which the Marine Biotechnology Center is one component, also has a center that focuses on advanced protein engineering, another that focuses on agricultural biotechnology, another on medical biotechnology, and another on bioprocess engineering. All of those

centers interact with marine biotechnology and can benefit the development of marine biotechnology in Maryland.

I said at the onset that the Japanese had chosen to focus a great deal of investment in the construction of a marine biotechnology research base in that country. The government of Japan recently announced a commitment of \$4 to 5 hundred million toward the development of a marine biotechnology center. The Ministry of International Trade and Industry in Japan has estimated the future market of marine biotechnology products to be \$15.4 billion annually. While I have no confidence that the market will be that large, it is significant that the Japanese think so and are planning accordingly. The U.S. can ill afford to bet that the Japanese are mistaken in the forecast, and I know of no better cost efficient mechanism for us to protect our future than investing in the Center for Marine Biotechnology.

Let me address one other aspect of the Christopher Columbus Center. It will have associated with it a program in maritime archaeology that is a partnership of NOAA, the Maryland Historic Trust, and the University of Maryland Baltimore County campus. The maritime archaeology program will have three foci. One is on discovering and excavating the nation's underwater archaeological artifacts; another is the development of technologies to preserve maritime artifacts once they are brought to the surface; and, a third is on the development of engineering technologies for discovering and bringing to the surface underwater archaeological artifacts. My campus of the university will devote a significant

part of its Mechanical and Electrical Engineering program to the development of underwater robotics. We expect to be able to do this research in conjunction with Martin Marietta and Westinghouse, both of which are located nearby our campus. The development of underwater robotic mechanisms should substantially aid the exploration of marine environments in search of organisms as well as archaeological artifacts. This is one aspect of marine biotechnology that I think may well receive less attention in Japan than in the United States. As marine biotechnology matures, and we begin to develop bio-enhanced technologies for mineral mining in the ocean, a sound base in underwater robotics should serve us well.

Let me just say finally that we are acutely aware as we plan maritime archaeology and marine biotechnology for Baltimore's Inner Harbor that the Inner Harbor represents an important resource to the nation in terms of its attractiveness to tourists. We see the opportunity to link tourism, and research through education. We expect to design the Center of Marine Biotechnology and the home of the Center for Underwater Archaeology in such a way as to enable visitors to pass through our laboratories where they can watch scientists at work. We will draw expertise from the National Aquarium's exhibition and education staff to design informative panels and exhibits to educate the visiting public regarding research that is being undertaken in marine biotechnology and underwater archaeology. It is especially fitting that the Christopher Columbus Center will link tourism in the Inner Harbor

with research to provide the public an appreciation of the knowledge-based economy that we are building for the nation's future.

Mr. McMILLEN. Thank you, Dr. Hooker.
Dr. Singleton?

**STATEMENT OF DR. FRED SINGLETON, EXECUTIVE DIRECTOR
AND ASSOCIATE RESEARCH SCIENTIST, CENTER OF MARINE
BIOTECHNOLOGY, MARYLAND BIOTECHNOLOGY INSTITUTE,
UNIVERSITY OF MARYLAND**

Dr. SINGLETON. Thank you. I appreciate the opportunity to appear before you today. I have written testimony that I would like to have entered into the record.

Mr. McMILLEN. Without objection, so ordered.

Dr. SINGLETON. I should also like to extend an apology from our director, Dr. Rita Colwell, who is attending the American Society for Microbiology meeting. She is being installed as president of the American Academy of Microbiology, one of her many honors.

I would like to deviate from the written text to really describe for you some of the projects that are ongoing at the Center of Marine Biotechnology and our philosophy that we have taken in carrying out our research programs. When we were established in 1985, we elected to take the avenue of being committed to fundamental, basic research in applying molecular biology and molecular genetics to the marine organisms and marine processes. As such, we have targeted three very, very broad categories of research: looking at fish, shellfish and algae; marine procaryotes, primarily marine bacteria, blue-greens, as some people like to say, blue-green algae—I like to refer to them, as most people, in terms of cyanobacteria; and we also targeted a third area, looking at what we loosely define as ecological processes.

In the interests of time, it is impossible to go through this in a very few minutes. I would prefer an hour or two to sit down and discuss this with you, but I would point out a few accomplishments that have been realized to date in this area.

In terms of aquaculture, we are looking at the molecular basis of the endocrinology of fish, how to control their reproduction. We are working with colleagues in Israel. This effort is being spearheaded by Dr. Thomas T. Chen, who was one of the first people in the world to successfully clone the growth hormone gene of fish. In Dr. Chen's work, from the fundamental side, his objective is to look at the evolution of growth hormone gene structure, function relationships. On the applied aspect of that, it is to apply this technology to aquaculture, to make fish grow to market size in a shorter period of time. He does not necessarily want to grow larger fish. It is to just make them get to market size quicker, which would increase the profit margin in an aquaculture industry.

As another example, we are studying the microorganisms that inhabit the deep sea hydrothermal vents. Some of the fluid that is exiting from these hydrothermal vents is at temperatures greater than 500 degrees centigrade, and there are living microorganisms in this fluid. It is contrary to what you will find in virtually any biological textbook. However, the results essentially speak for themselves. These organisms are adapted for growing at very high temperatures and high pressures. As such, they have the genetic

material to code for enzymes which are stable at very high temperatures.

We are also looking at the biodegradation of toxic compounds in the environment. Certainly the recent oil spill up in Alaska emphasizes the need for continued development and emphasizes also the application of genetic engineering of organisms which will function to degrade petroleum products at low temperature at a fairly rapid rate.

I should also like to mention another ecological process which has already been mentioned today, that being biofouling. We are looking at ecology of the organisms involved in biofouling. For example, how do organisms attach to surfaces? What leads to the formation of biofouling communities? Our approach here is to ask the fundamental questions and then use that information as a basis for developing technology which will allow us to inhibit biofouling without using a toxic compound. The recent problems that we have had in terms of tributyl-tin and other toxic materials in paints, antifouling paints, is an indication that we have to develop this technology.

The other area which I will mention—and once again in the interests of time having to miss many of these—is the area of marine pharmaceuticals. This has tremendous potential for benefit of all facets of society. We are looking at how organisms produce compounds that have antineoplastic or anticancer activity. We are looking at what these compounds do in the marine environment. We are developing an ecological strategy for pursuing other compounds. We know that many marine microorganisms produce antibiotics and antibiotic-like materials, and for the benefit of the disease process and treating diseases, we have to explore this technology.

We have the capabilities in place now. We are recognized as a unique program in the world. The Japanese have sent—I have lost count—it is 9 or 10 delegations to visit our center, and they are using it as a model for the programs they are building in Japan. Whether we remain the leader really depends on our resolve to do so.

Thank you.

[The prepared statement of Dr. Singleton follows:]

Statement by Dr. Fred Singleton, Executive Director and Associate Research Scientist, Center of Marine Biotechnology of the Maryland Biotechnology Institute, University of Maryland

I am Fred Singleton, Executive Director and Associate Research Scientist of the Center of Marine Biotechnology, Maryland Biotechnology Institute, University of Maryland.

I appreciate the opportunity to appear before you today to present a brief overview of the field of marine biotechnology. My statement is being made on behalf of all members of the faculty of the Center of Marine Biotechnology at the University of Maryland.

In only a few short years biotechnology, once viewed as the science of the future, has rapidly become the technology of the present. What began primarily as a descriptive science centered on the structure and function of proteins and nucleic acids has led to the development of specific techniques that are used in "genetic engineering" and other aspects of biotechnology. Prominent among the capabilities now available to scientists is the ability to identify specific genes and move them from one organism to another. This has generated intensive research efforts in both the basic and the applied sciences. As a result, this field is now yielding discoveries which will have a positive impact on many aspects of our lives.

Biotechnology per se is not a new scientific discipline. Indeed, for thousands of years, biotechnology has been employed in many endeavors: in the selection and breeding of farm animals; in fermentation processes to produce bread, wine and beer; in hybridization of crop plants to create desirable traits of growth rates, size, disease resistance, and yield. However, what is recognized today as biotechnology is based on the tools and techniques of modern molecular biology and molecular genetics.

Efforts to integrate new biological and biochemical technologies into commercial enterprises have been successful in many situations, especially those related to health-care. Still, the phenomenal potential and promise of biotechnology has yet to be fully recognized. Rapid advances in those scientific fields which contribute significantly to advances in biotechnology -- e.g., biochemistry, genetics, and microbiology, among others -- are stimulating additional basic research in many new areas. These advances pose novel questions to investigators and generate the basis for industries of the future.

The potential impact of biotechnology on society will be comparable to that of the development of the computer. Thus, scientists engaged in biotechnology-related research are considered by many to be at the forefront of a new scientific revolution. As an example of what can now be accomplished in biotechnology, a gene from one organism can be identified, excised, and then inserted into the genome of another organism. The recipient then has the ability to express a desired characteristic, such as the ability to make a useful product or to carry out a useful process. The implications of biotechnology for agriculture, medicine, aquaculture, and the pharmaceutical and chemical industries will be dramatic.

Throughout the United States, scientists in universities have been at the forefront of basic research in disciplines that support biotechnology. As applications for basic research discoveries have been found, universities have forged new partnerships for industry and government. The common goal of realizing the benefits of biotechnology requires the pooling of resources and the stimulation of basic and applied research, essential for large-scale development of this field.

Most biotechnology-related research has used terrestrial life for its base. Many of the forecasts of economic development and prospects for application in agriculture, medicine, and industry are also based, in large part, on terrestrial organisms and their products. However, the potential for tapping marine life for equivalent efforts is enormous. It is with the development of marine biotechnology that prospects for new scientific understanding of the wealth of ocean life and resultant economic benefits for society will begin to fulfill their exciting promises for the future. Thus, we must now apply this new biological knowledge to the world of marine plants and animals.

Marine biotechnology refers to the manipulation of marine organisms for improving goods and services to benefit humankind. There is a broad range of marine-related biotechnology endeavors. These include, among many others: enhancing production of fish and shellfish by aquaculture; waste treatment and biodegradation of pollutants; pharmacologically-active compounds; agrochemicals; disease detection and prevention; fine chemicals for industry; controlling the process of biofouling; and industrial applications of enzymes with unusual properties.

Why attempt to develop industries based on applying biotechnology to marine life? Marine waters cover approximately 71% of the earth's surface and harbor a wide variety of highly

diverse biological communities. It has been estimated that more than 500,000 species of marine animals exist in the world's oceans; a similar number of species of algae, bacteria, and fungi are distributed throughout the marine environment. These organisms represent a significant resource that can be used to stimulate economic development in many regions of the United States.

For centuries, humans have depended on the oceans for many products as well as an avenue for travel and trade. During the early years of the development of our society, food was harvested from the sea in much the same manner as from the land; people were hunter-gathers and they depended on natural stocks of organisms. However, society advanced from hunter-gatherers in exploiting terrestrial food crops to our current state of producing abundant food supplies with a technologically-advanced agricultural industry. The development of agriculture included the application of appropriate technologies to maximize production of desirable crops. Those technologies range from developing hybrid strains of plants and animals to the application of molecular genetics in agricultural biotechnology. As a result, we have capitalized on some of the metabolic potential of key crops, livestock and terrestrial microorganisms. We have not made similar accomplishments in utilizing marine resources.

Marine organisms possess a remarkable phenotypic diversity and, therefore, an even more varied and interesting genotypic diversity. Of the hundreds of thousands of marine organisms, only a relatively few have been studied in any detail. Fewer still have been examined at the genetic level; only limited information has been obtained from those organisms. Compared to what is known about the molecular genetics of *Escherichia coli*, we have, at best, only a rudimentary appreciation for the genetic diversity of marine life. A great deal of knowledge is to be gained from studies on the genetics of marine organisms; this knowledge will be required if we are to be successful in developing the important field of marine biotechnology.

Marine organisms survive and grow in habitats bounded by environmental parameters not encountered by terrestrial or freshwater organisms. As a consequence, marine organisms possess physiological characteristics optimal for an environment characterized by high salinity. Much of the biota of the oceans must cope with habitats characterized by seemingly harsh conditions. Most of the deep sea harbors communities of organisms that cope with ambient conditions of 4° C (or less), high hydrostatic pressure, and total darkness. In some regions of the floor of the deep sea, unique organisms survive and grow in

super-heated waters that enter the water column through hydrothermal vents. The water temperature of some hydrothermal vent fluids may exceed 250° C. The discovery of deep-sea thermal vents and the organisms which inhabit these deep ocean regions has generated a great deal of interest in recent years. The existence of abundant and active organisms in thermal vents has demonstrated to scientists that the metabolic potential of marine organisms is virtually unlimited. For example, recent studies on microorganisms isolated from extremely hot water collected from thermal vents have demonstrated a variety of potentially important industrial applications of thermostable enzymes.

Organisms that inhabit tropical marine waters possess specific traits for survival in highly diverse and competitive habitats; because of this, they are subjected to strong selective pressures from biotic and abiotic factors in their environment. As a result of selective pressures, a variety of offensive and defensive mechanisms have evolved to allow organisms to gain a selective advantage and to cope with competitors. The physiological manifestations of offensive and defensive abilities of marine organisms are usually in the form of bioactive metabolites (i.e., toxins). Many marine animals produce specific toxins that are used to capture prey and to deter predators. Bioactive metabolites are excellent candidates for a variety of applications in the pharmaceutical and agrochemical industries.

The benefits of the development of new and, perhaps, high technology marine-based industries will be many. We can use this technology to reduce or eliminate threats that harvesting from natural stocks of marine life pose to sensitive habitats and organisms. We can employ recombinant DNA techniques to clone the genes which code for a particular product or process into an organism amenable to cultivation in the laboratory. Also, advanced technology applied to aquaculture can be employed to produce large quantities of selected organisms. These approaches take on added importance when a useful compound is produced by a rare or "fragile" species and harvests from natural stocks is not practical.

Aquaculture is especially attractive for advancements by modern biotechnology. There are urgent needs for rapid advancements in enhancing the production of fish and shellfish by aquaculture. In the past, the oceans were considered as a source of an infinite supply of consumable fish, shellfish, and crustaceans. This unfortunate view resulted not only in over-harvesting of natural stocks, but it provided no incentives to developing aquaculture-based industries to produce commercially-important marine life. This situation is changing rapidly as it becomes more apparent that natural stocks cannot

meet the demand for many marine organisms and their products. For example, harvests of finfish from the oceans has peaked in recent years at a level of approximately 70 million metric tons. Likewise, the natural stocks of marine algae cannot satisfy the demand for these organisms and their products.

The aquaculture industry can have a substantial economic impact on the economy of many regions, especially those with abundant coastal resources. The economic base of Maryland and many other states can be enhanced by aquaculture, especially by incorporating genetic engineering to the production of fish, molluscs, and crustaceans in hatcheries and in the natural environment. Significant advances can be made in applied genetics of foodstock species through laboratory manipulations of the genetic material of these species; a great deal of progress is being made in this area. For example, investigators at the University of Maryland's Center of Marine Biotechnology have succeeded in identifying and cloning the growth hormone gene of selected commercially-important fish species. Fish that receive injections of growth hormone produced by recombinant DNA techniques grow much faster than those not receiving the hormone. In some experiments, the growth rate of hormone-treated fish is two-times that of untreated fish. The primary objective of this research is to develop techniques to make fish grow to market size in a shorter time period.

Other major advances in aquaculture production of fish and shellfish will be realized by developing new methods of diagnosis and control of diseases that affect this industry. The aquaculture industry loses as much as thirty percent of its production as a result of outbreaks of infectious microorganisms and viruses. There is an urgent need for safe and effective vaccines to prevent outbreaks of such diseases. Likewise, rapid and reliable methods for detecting disease-causing agents before outbreaks occur.

Marine biotechnology may provide the means to develop strains of fish and shellfish that are resistant to disease agents. This is important especially for the shellfish industry. For example, MSX, an important disease of oysters, has contributed significantly to the declining stocks of oysters in Chesapeake Bay. It is not unreasonable to predict that tools and techniques of marine biotechnology can be used to make significant advancements in lessening the impact of MSX and other diseases of shellfish in Chesapeake Bay and in coastal waters of other states.

An important research program at the University of Maryland Center of Marine Biotechnology with direct application to

aquaculture is focused on the processes of molluscan larval attachment to surfaces. Researchers have discovered a bacterium, labeled LST, that serves an important role in the attraction, settlement and metamorphosis of oyster larvae. Prospects for developing a chemical attractant capable of inducing larval setting and metamorphosis promise significant improvement in the productivity of oyster hatcheries, and a patent is pending on this new bacterium. In related projects, research is underway to genetically engineer this versatile bacteria, not only to elucidate the chemical and biological processes of marine biofouling but also to explore the potential for submarine adhesives and other products. These technologies have resulted in the formation of two companies in Maryland.

Studies relevant to the biotechnology of the aquaculture industry have already resulted in the formation of new companies in Maryland and in other states. Currently, other companies are being formed in Maryland to capitalize on the opportunities of high-technology approaches to aquaculture.

In most countries there have been few, if any, incentives for applying the experience gained from agriculture to cultivating and harvesting marine organisms. Some countries, e.g., China and Japan, have directed efforts toward producing crops of seaweeds in coastal waters. Although labor-intensive, these efforts have usually been successful. There are now many incentives for farming some regions of the marine environment. Those incentives are increasing with the increasing demand for marine organisms and marine products. Furthermore, as the demand for marine products continues to increase, the economics of marine-related industries will become more favorable. This, in turn, will stimulate the development of new industries.

Marine algae represent significant potential for marine biotechnology industries. Estimates of the world market for macroalgae vary. However, the wholesale value of chemicals extracted from macroalgae is between \$0.5 and 1.0 billion. The estimated market value in Japan and China for edible seaweeds is more than \$1.2 billion dollars. Certainly, these markets should continue to expand in the future.

The structural polysaccharides (phycocolloids) of marine algae are in the most demand. Phycocolloids from seaweeds are nearly ubiquitous in Western households and in a variety of industries. Alginates, carrageenans, and agar all comprise the three general classes of phycocolloids. They are utilized predominantly as gelling agents, stabilizers and emulsifiers. Alginates derived from brown algae (*Laminaria*, *Macrocystis*, *Ascophyllum*) are found in many products including dairy products,

baked goods, toothpaste, shampoo, and in dyes and paints. More than 60% of the world's supply of alginates is utilized in the paper and textile industries. Carrageenans isolated from red algae can be found in a variety of processed foods.

Agar, extracted primarily from *Gelidium* sp. has perhaps the longest history of use as a gelling agent. Several different types of agar with differing chemical purities are now being used. Lesser grades find applications in foods while more purified forms are chiefly used in microbiological culture media. As an indication of the demand for agar, consider its retail price during the 1980's. From 1981 to the present, the retail price for laboratory agar has increased by approximately \$70 per pound (from \$14 to \$84 per pound). During the past year alone, the price has risen by approximately 55%.

Dramatic increases in the price of agar has an impact on research related to biotechnology. Gel electrophoresis, a cornerstone technique in biotechnology requires the use of a highly purified form of agar, agarose. The price of agarose has increased proportionately to that of agar during the past few years.

Marine pharmaceuticals provide researchers in marine biotechnology with a resource that has yet to be evaluated completely. Numerous compounds have been identified with a spectrum of activity ranging from antibacterial to anticancer to cardiostimulant and androgenic, including a wide variety of compounds from the sea which act on the cardiovascular and central nervous systems. Marine natural products (and those of any natural source) of high pharmacologic activity are unsurpassed by synthetic compounds. Researchers actively involved in investigating marine natural products with pharmacologic activity report that only a small fraction of such compounds have been identified and described. In addition to providing a direct source of novel drugs for use in experimental and medical applications, marine natural products will serve as models for synthesis or improvement of other drugs. Studies have demonstrated that the marine environment contains numerous bioactive compounds that have cytotoxic or antineoplastic activity that may be useful in the treatment of some forms of cancer.

Marine microalgae also have great potential for enhancing the development of marine biotechnology. It has been estimated that only a very small percentage of the thousands of strains of marine microalgae have been screened for vitamins, pharmaceuticals or biochemicals. Only a relatively modest effort has been directed toward commercial cultivation of microalgae.

These efforts have been directed toward producing algae as a source of food or food supplements or for fine chemical production. However, the market potential of these organisms has not been exploited to any significant degree. This should happen in the future as improvements are made in the technology required for their cultivation and as more strains with highly desirable characteristics are isolated or developed in the laboratory. For instance, we now have the capability to culture *Dunelliella salina* in such a manner that over 50% of its dry weight is glycerol. Although current production of glycerol is petroleum based, a renewable alternative must receive appropriate attention.

The economics of microalgal production of specific chemicals will improve as technology advances. For example, cells of some strains of microalgae comprised of as much as 72% lipids have been isolated. These lipids can be converted to a high quality energy source. However, this fuel is still far more expensive than conventional fossil-derived sources. The application of techniques of molecular biology and molecular genetics to these organisms may result in strains with faster growth rates and increased production of lipids. The economics of microalgal cultivation should, in turn, improve as technology advances. Additional research is required if we are to capitalize on these organisms.

Metabolic products of marine organisms have significant potential as pharmaceutical compounds. The pharmaceutical industry is very large (more than \$3 billion in the United States) and requires constant influx of new compounds. Many species of marine organisms have yielded hundreds of natural products with unusual structures and activities. The reported activities of natural products isolated from marine organisms vary widely. Some activities reported for bioactive marine metabolites include antimicrobial, antineoplastic, antihelminthic, cytotoxic, anticoagulant, cardiogenic, among others, hypocholesterolemic. Thus, such compounds are excellent candidates for use in developing industries in marine pharmacology.

Bioactive metabolites from marine organisms may also have applications in agriculture. "Agrochemicals" have a multi-billion dollar market. Marine natural products from algae have great promise in this market and emphasis should be placed on developing this potential. Certainly, there are needs for compounds with activity as pesticides and herbicides as well as plant growth regulators.

Since terrestrial microorganisms are the source of most antibiotics in use today, it is reasonable to assume that marine microorganisms will prove to be a source of many useful compounds. Many investigators have demonstrated that some marine bacteria produce metabolites with specific bioactive properties. Studies have been carried out over a forty year period that have demonstrated the ability of some marine bacteria to produce antibiotic-like compounds. Only in recent years have significant advances been realized in the chemistry of marine bacteria and fungi and their secondary metabolites. This is an area that is ready for exploitation by the pharmaceutical industry.

Basic studies on the ecology of marine organisms and processes in the marine environment will help stimulate the development of marine biotechnology. For example, significant promise in marine biotechnology lies in the development of methods for controlling the biofouling of ships and other surfaces exposed to ocean water. The presence of biofouling organisms on the hull of a ship, for example, can increase fuel consumption by more than one hundred percent. The efficiency of heat exchangers can be reduced dramatically as a result of the presence of biofouling organisms. There are, therefore, obvious needs for developing methods to control or prevent biofouling. Studies carried out at the University of Maryland have demonstrated that specific marine bacteria may be involved in attracting biofouling invertebrates to surfaces in the marine environment. An understanding of such relationships will aid in the attempt to control the presence and abundance of fouling organisms.

In order to take advantage of the unique opportunities of marine biotechnology, a multidisciplinary approach is required. Such an approach must include scientists trained in appropriate areas of the marine sciences with those trained in molecular biology and molecular genetics. Such an approach is being taken at the University of Maryland Center of Marine Biotechnology.

The essential elements for maintaining national and international leadership in marine biotechnology now exist in the State of Maryland. The State is already attracting biotechnology and high technology industry. Opportunities to attract new industry and to build mutually supportive research and development activities are virtually unlimited. Such a commitment will ensure the United States maintains a leadership role in high technology. The University of Maryland Center of Marine Biotechnology will be an invaluable resource for the University, the State of Maryland, the nation--and for the growing pool of scientific knowledge applied to the world's rivers, estuaries, and oceans.

Biotechnology brings a new dimension to the marine sciences that offers to expand dramatically the use of marine and estuarine resources. It will provide new tools for the study of complex marine problems. To realize this potential will require an initiative that pools the resources of the research-oriented university with those of industry and government. To date, there have been only a few directed efforts throughout the country in this regard. Such efforts have been without any unified program to bring together the wealth of expertise in biotechnology and the marine sciences necessary to capitalize on the potential of marine biotechnology.

At the University of Maryland Center of Marine Biotechnology, we have established a unique program in this field. As a result, we have helped place the United States in a leadership role in marine biotechnology. Our program is based on the pursuit of fundamental research on the molecular biology and molecular genetics of marine organisms and marine processes. As an indication of the success of our program and the potential of marine biotechnology, other countries are using the Center of Marine Biotechnology as a model for establishing initiatives in this field. Certainly, the Japanese government has recognized this potential and has invested substantial resources to capitalize on the potential of this field. We believe that it is in the best interest of our nation to maintain a leadership role in this important field of research.

Mr. McMILLEN. Thank you, Dr. Singleton.
Dr. Perkins?

STATEMENT OF DR. FRANK O. PERKINS, DEAN, SCHOOL OF MARINE SCIENCE, AND DIRECTOR, VIRGINIA INSTITUTE OF MARINE SCIENCE, COLLEGE OF WILLIAM AND MARY

Mr. PERKINS. Thank you, Mr. Chairman. I apologize for being late. My airline was moving a little slow this morning.

I appreciate the opportunity to submit comments on the potential value and importance of centers which would include biotechnology, aquaculture, and underwater archaeology. I am Frank O. Perkins, Dean/Director of the School of Marine Science/Virginia Institute of Marine Science of the College of William and Mary. We are an institute engaged in a diversity of research and graduate education efforts related to the estuarine and coastal environments, particularly the Chesapeake Bay area. I won't try to masquerade as an authority on biotechnology, but I have made a few observations which may be of interest after working 28 years in the field.

I have come to the realization that there is a great potential for mankind to profit from the utilization of marine and estuarine life forms which have evolved over 3.5 million years of the Earth's history—or 3.8 in some people's minds, we won't quibble over a few hundred thousand. The diversity of species and biochemical pathways which have emerged from that extremely long time span lead one to believe that there is a wealth of existing organisms and pharmacologically active chemicals which could be used to the advantage of mankind.

We have seen evidence in a few cases that such a potential exists. For example, antiviral and antitumor agents alluded to already have been discovered from a wide diversity of marine organisms. Since these few cases were derived from limited research efforts—as compared to medical research—one can legitimately surmise that an increased research effort in marine biotechnology will lead to more discoveries that will ultimately have great significance for human health. Beyond the value of extracting useful biochemicals which exist in nature lies the potential for generating in the laboratory large quantities of the identified chemical agents by isolation of the genes responsible for their synthesis, followed by incorporation of those genes into microbes which can utilize them in mass production of the desired agents.

On another front, efforts should continue in the generation of microbes which can serve as agents for the cleanup of manmade toxics from the environment. There are a lot of unbelievers in this field at the moment, and I must admit that I have some reservations myself, but there is a tremendous potential there and the research must continue.

At our Virginia Institute of Marine Science, we have a multidisciplinary program dedicated to identifying the primary toxics which do threaten the biota of the Chesapeake Bay and investigating the effects of those toxics in the estuarine environment. A biotechnology center conducting research designed to genetically engineer microbes to digest toxins would complement our efforts at the

Institute as well as others, in that the direct solutions to the identified and quantified toxin problems would be sought.

The task of cleanup by microbes is formidable, because often the anthropogenic chemicals are highly resistant to degradation by biological systems—thus, the reason for their long half-life in the environment. However, it is obvious that the rewards for society could be great. Anxiety over releasing of an exotic microbe into the environment could be lessened if the toxic substance were a limiting nutritional factor which, when exhausted, would result in death of the engineered microbe.

Another potential contribution which could result from marine biotechnology has already been mentioned, and it is in terms of biofouling, so I don't think I need to hammer away at that theme again. We need to find a substitute for tributyl-tin. It is incredibly effective. You have to repaint the vessel every five to seven years, as opposed to a copper-based paint every one to three years. That is a big difference, so there was a great significance to the U.S. Navy when they talked about saving \$250 million a year in costs, not having to paint with copper-based paints. It was very unfortunate, but if we can find a substitute that is not damaging to the environment, we will all be well served. The scientific community must not limit its efforts to finding fault with products produced by industry, but must continue with investigations to find solutions, and of course that is what biotechnology is all about.

It also holds the potential for improved production of seafood organisms, as I already mentioned. Fish and shellfish are already being cultured in several regions of the United States, including the Chesapeake Bay. The time required to reach market size can be shortened, resistance to diseases increased, size and quality of the marketable product improved, and the density of cultured populations increased, all through this biotechnology route.

Many of the techniques developed in medicine, animal husbandry, agriculture, can be used with marine organisms, thus shortening the time to a useful product. For example, the techniques of microencapsulation of organic particles could be developed—have been developed—and further research can lead to the encapsulation of food for feeding larval shellfish, fish fry, or larvae, thus increasing yields of juveniles for culture and in grow-out waters after release from the hatchery facilities.

Although we are all trying to reduce the level of pollution in our estuarine waters, particularly the Chesapeake Bay, it is still likely that in the future there will be fewer bodies of water suitable for culture of seafood species. Thus, intensive, high-density culture will be necessary in the remaining suitable waters. Of equal importance, such culture is more viable from an economic standpoint. High density culture is, of course, made possible by controlled feeding of organisms with readily available and nutritious food.

As with the mass generation of pharmacologically active biochemicals already mentioned, genetic engineering techniques can be used to provide means which will stimulate growth and disease resistance. A few figures may be of interest: With the continuing decline of seafood harvesting in our waters and the very large seafood trade deficit of \$7.1 billion in 1987, it is obvious we must begin farming our waters. Clearly the market demand is high and the

gathering and harvesting approach to meeting that demand is not adequate, particularly with the estuarine species.

There is no question that aquaculture does and will contribute even more significantly in the future to products available in the marketplace. As noted in the National Sea Grant Program's annual report for Fiscal Year 1988 on aquaculture, "In 1988 approximately 22 percent of the shrimp placed on world markets was produced on shrimp farms. This production was valued at \$2.5 billion at wholesale prices." To help realize the full potential of aquaculture in the Chesapeake Bay Region, it is necessary that an aquaculture research center be established in the Bay region.

Now I am really getting out of my field of expertise, but I can't resist the opportunity to comment on underwater archaeology. I have a personal interest in it.

Any truly comprehensive program of maritime research and exploration should encompass cultural as well as natural resources. Chesapeake Bay communities share a rich and varied maritime heritage which begins with Native American coastal villages and dugout canoes, expands with the arrival of Spanish and English explorers, and flourishes with the English settlement and trade in the 17th century. Reports of European shipwrecks in the Chesapeake Bay date back to at least the 16th century, as do reports of European coastal settlements and missions.

Location and scientific examination of submerged cultural resources, however, can be a difficult and costly endeavor. A broad-based program of maritime research promises to maximize efficiency, productivity, and quality of results. Such a program should include resources in marine technology, historical and archaeological research, museum interpretation and curation, all coordinated by a joint management structure. Such a comprehensive program, applied to the Chesapeake region, would be an effective means of studying and interpreting our common maritime heritage and making the results available to other scholars and the general public as well.

Thank you again for the opportunity to participate. I wish you success with your deliberations.

Mr. McMILLEN. Thank you very much, gentlemen, for your testimony and your comments on the future of aquaculture and marine biotechnology in our State and in our country.

Mr. Carey, I have some questions that I would like to direct to you. As I am sure you are aware, last week there was a great deal of controversy in Washington concerning the testimony of Dr. James Hansen of NASA with respect to the greenhouse effect, an issue that this committee has a strong interest in. Are you familiar with that controversy, Mr. Carey?

Mr. CAREY. Yes, sir, I am.

Mr. McMILLEN. As you know, Dr. Hansen told a Senate panel that his testimony containing scientific views of the greenhouse effect had been altered at the insistence of the Office of Management and Budget. Now is it correct to say that your testimony was also reviewed by the Office of Management and Budget before your appearance here today?

Mr. CAREY. Well, sir, I happen to have had the advantage last week of not being in Washington. I was in New York, so my views

of that came from the newspapers up there and not from direct knowledge of what was going on. I returned to Washington this weekend. My testimony which has been submitted for the record was prepared and was submitted to OMB for its clearance process, as is the normal process.

Mr. McMILLEN. So the answer is that OMB did review your statement prior to its introduction today?

Mr. CAREY. Yes.

Mr. McMILLEN. Is it also safe to say that OMB made changes or additions to your statement? In fact, isn't it the case that your statement opposing Federal funding for the Columbus Center is actually an OMB statement?

Mr. CAREY. Again, Mr. Chairman, as I was away last week, I was not directly involved in the preparation of it, so I am not clear as to what pieces of the testimony or how that was put together. You are correct, though. The statement submitted for the record does indicate that the administration opposes direct appropriations for the construction and operation of the center.

As you know, the backdrop of that really involves the broader question that you and all of the Members of Congress, Mr. Chairman, have been struggling with, and that is the problem that we face with the Federal deficit. That is a very real concern, and obviously projects and proposals for the utilization of Federal funds are undergoing very close scrutiny in Washington with respect to the impact that they do have on the overall Federal budget. It is a fact of life. It is something that we are all struggling with, and we are all struggling to figure out how to work the right set of priorities within that budget constraint.

Mr. McMILLEN. I mean, we all have to deal with the constraints of the Federal budget deficit, but what I am trying to get at in this questioning here is, we are in a situation where we cannot learn your own opinion. We seem to have a gag rule applied to Federal officials.

The concern that I have is that I learned from the subcommittee staff that in your original testimony, the assertion that your agency would not support the Federal funding for this project was not in fact in that testimony, and it had since been added in at the insistence of OMB. My concern is, as one of the Nation's top marine science officials, we are trying to get an idea from you as to the merits of this particular proposal, and not have a gag rule imposed, if you will, by OMB as it was in the case of the greenhouse effect. We understand the budgetary dilemmas that we are facing, but is that an accurate depiction, that your earlier statement did not have that represented?

Mr. CAREY. Again, Mr. Chairman, I am not sure. I understand your concern over that. As I indicated or tried to indicate in my remarks, as far as the National Oceanic and Atmospheric Administration is concerned, we support the center. We are very excited about the center.

We are very much involved, as I have indicated, in working with the States in this region on a daily basis. We have a lot of programs that we work cooperatively with the Chesapeake Bay programs. We have embarked on this new National Marine Preservation Technology Center. We are funding that within our current

budget. We have within our current budget monies that are going into the Chesapeake Bay Program. We are making every effort, concerted effort, to try and put the resources behind these important problems.

As the center develops and as it proceeds, we most certainly want to be involved. We see a lot of areas. There is our Sea Grant Program, for example, which has been involved in the biotechnology area for a number of years. Our National Sea Grant Program has supported a lot of work of my colleagues here, of Dr. Colwell and her research work, and we see this as a great opportunity not only for the Nation and the State but for NOAA as well, in terms of getting at some of these. We are going to have to leverage the resources at the local, Federal, State level, wherever, if we are going to get the job done, because I don't think anyone these days has the total resources or the total knowledge, as a matter of fact, to really attack these problems.

Mr. McMILLEN. Let me just say that I appreciate your agency's support for these kinds of efforts. Again, what I was trying to ferret out here is the imposition of these kinds of constraints from OMB, which by the way are contradictory with President Bush's own budget, which states:

"The ability of the Nation to meet global competition, to provide for the national security and to improve the quality of life for all citizens, depends in part on the national investment in science and technology, and the 1990 Federal Budget continues to reflect the strong emphasis that this administration has placed on enhancing support for basic research across all scientific and engineering disciplines. Even in an environment of continuing fiscal austerity, Federal support for basic research, especially at universities, is an important factor in generating new knowledge to ensure continued technological innovation."

I am going to stop my questions there and defer to the Chairman. Mr. Scheuer had a couple of follow-up comments on that.

Mr. SCHEUER. Well, I am not sure I do, Mr. Chairman. Mr. Carey was very forthright in his testimony, and his testimony states, in haec verba, that NOAA supports the establishment of the Christopher Columbus Center but does not support direct Federal funding for the construction or operation of the facility. Now that is the condition that prevails.

In the other case, in Dr. Hansen's case, I believe words were inserted where he stated as his own point of view thus and so. Now nobody substituted a sentence or two in here saying that you opposed funding. If that had happened, then I think we would have gotten an incorrect statement of your views.

Mr. CAREY. Correct, sir.

Mr. SCHEUER. But this is a perfectly forthright statement that NOAA does not support direct funding for the construction or operation of the facility. As Members of Congress we can agree or disagree with that, but what you see is what you get, and it is an honest, forthright statement.

Could I ask you whether you think it would be a good investment of Federal funds, assuming they could find the money, to help build this facility to provide a home for this state-of-the-art, high-technology research in mining the riches of the sea? Would that be a—

Mr. CAREY. Mr. Chairman, I am going to echo something that was stated earlier. Last week, as I said, I was out of Washington. I happen to have been in New York, and I attended an international symposium on coastal ocean space utilization, and—

Mr. SCHEUER. Coastal ocean—

Mr. CAREY. Space utilization, use of the coastal and ocean areas. At this symposium were representatives from a number of countries around the world—from the European countries, from the Netherlands, the U.K., Israel, Jordan, China, Korea, the Soviet Union and Japan. I walked away from that—

Mr. SCHEUER. Was Egypt represented?

Mr. CAREY. No, sir, it was not. I walked away from that symposium just amazed at the amount of activity that is going on—it has been referred to earlier here—in these countries. Aquaculture, as you have mentioned, is going on in Israel. Development of the coastal spaces for artificial islands for use in marine biotechnology has been referred to in Japan.

I came back to Washington convinced, after sitting there through these presentations that were made by these other representatives from these other countries, that the United States does need to get on the ball and begin to move in these areas. I think that the proposal that we are hearing here is truly a national proposal. It is one that will help the United States be competitive and to keep in line with what is going on elsewhere in the world, and we have to do that.

Mr. SCHEUER. Well, I appreciate that very forthright statement. I just want to footnote your statement and my statement before, that the biotechnology science that is developing very rapidly in Israel is being shared very intensively with the Egyptians and hopefully very soon the Jordanians.

Mr. CAREY. Yes.

Mr. SCHEUER. I visited Israel in November, and there were eight or nine Egyptian scientists of top quality. The head of the marine biology science establishment in Egypt, a gentleman in his eighties and a world-renowned scholar, he and seven or eight of his colleagues were collaborating with the Israelis with the highest satisfaction. There is technology transfer taking place. The Israelis are helping the Egyptians set up a marine biology establishment and a fish farming capability, aquaculture, mariculture. At the present time Egypt, with its teeming millions, is importing fish and spending its hard currency to do so.

The Israelis and the Egyptians are engaged in a joint scientific effort, science sharing, that will convert Egypt into a fish exporter rather than being a fish importer. The Jordanians are very eager to participate, and down the road they tell me the Saudi Arabians, all of whom front on the Gulf of Elath, are interested in working together on joint measures in not only aquaculture but also in preserving the marine environment of the Gulf of Elath. It is really about the only cooperative effort between Israel and any of the Arab states, the Arab peoples.

I guess the reason that it is taking place is—and with great enthusiasm—is that the Arabs see this as a tremendously important field for them to get into and get into fast, as a means of feeding their millions. If you think about the implications of aquaculture

for the developing countries of the world, for any country that fronts on an ocean or a bay or an estuary, the implications are mind-boggling in terms of feeding the human race 10 or 20 years from now.

Well, I appreciated your testimony very much, all of you.

Yes?

Mr. PERKINS. Mr. Chairman, I worked on an oyster farm in Elath, Israel, at the Elath Marine Lab for a while, and I can report that in 1981 at least they were raising the European flat oyster and the Pacific oyster from the fertilized eggs to market in 11 or 12 months, very impressive. With those warm waters, things can be done that you wouldn't normally expect—with oysters that are normally cold-water oysters, also, I might add.

Mr. McMILLEN. Kweisi?

Mr. MFUME. Mr. Carey, I listened to your testimony and there was one thing that I would like you to take a moment to expand on, if you would. Dr. Hooker, who sits to your right, came to visit me several months ago in Washington and started talking at that time about this project and the tremendous potential that it held.

Aside from the biotechnology aspect of it—like in this case—Dr. Perkins found a great deal of fascination in this whole aspect of underwater archaeology, particularly shipwrecks, and was fascinated to learn of the number of shipwrecks that have occurred in the Chesapeake Bay—hundreds and hundreds that really represent, I think, a link and a bridge to past civilizations, but also a tremendous opportunity for us to be able to fill in some of the missing pieces in terms of archaeology that we are perplexed by and bewildered by in this society. I would appreciate if you could take a moment to talk about how NOAA views this whole area of underwater archaeology, particularly in support of, as you indicated, a center of this type.

Mr. CAREY. Well, as I made a reference to in my statement, we have embarked on a cooperative program with the State of Maryland to move forward with a National Center for Marine Preservation and Technology. As a matter of fact, that memorandum of understanding and agreement between NOAA and the State of Maryland was signed here in Baltimore last fall.

The program is in its early stages. We have staff which are co-located and will be co-located with the State of Maryland people. We are looking at developing a model program, one that can be used in other States, that can be transferred to other States to help them set up similar types of executive structures and legislative programs for protection of these many shipwrecks that you point out. There is a lot of public interest in it, and we do have problems out there. We have people going out that are diving on the shipwrecks, that are removing pieces of artifacts. We don't have a good handle on that.

The Abandoned Shipwreck Act legislation that the Congress passed is an important step which moves us in the direction of being able to put together a national management program, and working cooperatively with the State of Maryland, we think we are in the vanguard, moving that one forward. It is an extremely important area, not only for public education but for preserving the marine history and heritage of our Nation which is there.

Mr. MFUME. Does NOAA have any suggestions for legislation, avenues to be considered legislatively that would sort of go hand-in-glove with the security side, the Abandoned Shipwreck Act, that would further bring about a sense of order in terms of recovery of artifacts and at the same time to bring about a greater sense of order in how we move as a society, both Federal, State and local, in working together, or in this case in working with NOAA?

Mr. CAREY. I welcome your question. Right now I don't think we have an answer for you, but again, it is the kind of work that we are doing with the State of Maryland and with Rodney Little and his people that are helping us move in that direction. I think once we get the model program in place, we will have a better handle on knowing whether or not there need to be any further changes made at the Federal level through that legislation.

Mr. MFUME. Dr. Hooker?

Mr. HOOKER. Yes, sir. Congressman Mfume, OMB doesn't review my testimony, so I can say that I think really the Shipwreck Act, the Abandoned Shipwreck Act, provides the structure, and NOAA provides the agency, and I think congressionally reviewed appropriations in this area to NOAA for the NOAA budget, while NOAA may not be in a position to request it, I think that there is a lot to be done and the funding that is presently available for it is minuscule compared with the magnitude of the task ahead.

Mr. McMILLEN. Just a couple of follow-up questions, Dr. Hooker. Because of the current interest in the Valdez oil spill, could you say, how close are we to the potential of a marine organism that can consume toxic materials like oil, and would that type of organism be able to function in a spill like the one we saw in Valdez?

Mr. HOOKER. We have organisms now and we have had organisms for some years. The first biotech patent, as you know, was on a bacterium that consumes oil and metabolizes it and breaks it down. The problem is that the Valdez spill was simply so large that any application of present biotechnology to the spill would have been impractical.

Now had we done more research in the last 10 years, we probably would have had a spill cleanup technology available to us that could have been applied in the Valdez incident, but there just hasn't been that much research, at least federally sponsored. What research there has been, for the most part, has been industry-sponsored, and the industry recognizes the potential for profit here in toxic waste cleanup, but the research simply hasn't been done to enable us to deal with something as large as the Valdez spill. It is highly probable that we could have, had we set out 10 years ago to focus on toxic waste cleanup with genetically engineered organisms, it is highly probable that we would have been able to contain the Valdez spill.

Mr. McMILLEN. Then this could be, in your view, one of the direct offshoots of this Christopher Columbus Center, the kind of research that 10 years from now could lead us to a biotechnological solution to a spill like that?

Mr. HOOKER. There are two kinds of research that we are presently doing at the Center of Marine Biotechnology, both of which have application. One is in toxic waste detection. Let me give you an example.

Looking at the marine environment, eels can detect molecules in water of a few parts per million. They have an acute sense of smell detection. That is how they find their food. Whatever mechanism it is that enables the eel to sense a few parts per million, it is a biotechnology-based mechanism. It is highly probable that we could marry that with microelectric processors, sensors, and produce biosensors that would enable us to comb the oceans to detect toxic waste spills.

We could put those biosensors in the sludge at the bottom of the harbor, detect toxic wastes, pockets of toxic wastes, and once we detect them, then a second wave of technology toward biodegradation of toxic waste would enable us to go in and clean it up. For the most part the really lethal chemicals that are in the sludges at the bottoms of our harbors are not of the volume of magnitude of the Valdez spill. They are fairly small pockets of waste, but they are highly toxic, very carcinogenic, and so there is a challenge in detecting them; once they are detected, there is a challenge in producing biodegradation. So if at the end of a few parts per million, it is reasonable that we can clean up those spills, eventually it is also reasonable that we will be able to clean up future Valdez spills, once we have done the research.

Mr. McMILLEN. And you could see that happening in a 10-year time frame?

Mr. HOOKER. One of the things I have learned about forecasts in biotechnology is that when the event finally comes to pass, our forecasts were laughably conservative. Biotechnology is one area that seems to proceed ahead of our forecasts. In recognizing that, I now make what sound like hyperbolic guesses and damage my credibility in doing so, so I won't say 10 years but I will say 15.

Mr. McMILLEN. Thank you. You know, getting on to this point, the next question I would ask Dr. Singleton or Dr. Hooker is about the risk involved in introducing these nonindigenous organisms to a population of indigenous organisms. We read about the Gypsy Moth and the Pacific oyster and all the problems that have resulted from those species. How would you perceive the risk? How would you manage the risk? Is that something we have to be concerned about?

Mr. SINGLETON. Well, I believe this is something that we all have to be familiar with and to look at the potential damage and to also look at the potential benefits. When you are genetically engineering a microorganism it is quite feasible to insert a specific type of gene so that when the organism finishes degrading that particular compound, it will turn that gene off that was producing that enzyme. It will turn that gene off. When that happens, you can engineer an organism so that it will set into action a cascade of events, so that the organism will kill itself. Mother Nature has had, say, 3 or 3.5 billion years to select for organisms with specific characteristics. If the insertion of a particular gene would confer such a selective advantage onto an organism that it would proliferate wildly in the environment, it probably has already occurred to a large extent.

Now I don't want to oversimplify. We also have to be aware that, you know, there are dangers involved. For example, as you mentioned, you can drive down the roads in some States and look at

the kudzu that is growing. Things like this, I believe if we are aware of them and we take the proper approach, then we can make the proper safeguards.

Mr. McMILLEN. How about the hydrilla in the Potomac? That is on the lower part of my district. Believe me, that is a very vexing problem.

Mr. SINGLETON. Well, I mean, one can also look at the bright side of it, in that that organism, that plant, does a tremendous benefit in terms of taking up micronutrients and cleaning or improving water quality, so there is always a trade-off.

Mr. McMILLEN. Would this proposed center be a good investment by the Federal Government in an effort to better understand the effects of marine pollution, in your view, Dr. Hooker?

Mr. HOOKER. Absolutely. As we have said before, both detection and degradation of marine pollution. The benefits are innumerable. I don't mean to beat a dead horse, but I have pointed before to the activity of the Japanese. The Ministry of Trade and Industry went to the universities in Japan, asking them to participate in marine biotechnology. In Singapore, the Economic Development Board went to the National University of Singapore, asking them to develop a program in marine biotechnology. I say this not in bitterness so much as in sadness. In our case we are begging the Federal Government to let us do what we know we have the capacity to do, which would be of enormous benefit to the Nation, to the economy of the Nation, to its future, and one of the areas of course is pollution detection and control.

Mr. McMILLEN. Any other questions, Mr. Chairman?

Mr. SCHEUER. How many universities are involved in the work of this center?

Mr. HOOKER. The two primary universities involved are Johns Hopkins and the University of Maryland, but Stanford University is also involved through the participation of the director of the Marine Biotechnology Laboratory at Stanford, and we bring in other scientists for conferences, for joint projects in collaboration. We are collaborating with the Office of Naval Research, for example, so it is truly an international center. We have had three Israeli delegations through recently. We have had Heaven knows how many Japanese delegations through. It is a unique center in this country, really at the present time unique in the world, and it is truly an international center.

Mr. SCHEUER. Is your Virginia Institute of Marine Sciences involved in an ongoing way?

Mr. PERKINS. We have not been directly involved with it thus far. We, as I mentioned before, are helpful in a complementary type of interaction.

Mr. SCHEUER. You see no problems in having several academic institutions involved in a collaborative, cooperative effort?

Mr. HOOKER. Well, part of the joy of biotechnology is that it is a pioneering technology, and this pioneer spirit infuses the academics who participate in it. They are more interested in collaboration than in competition, and I think you have seen a shift of understanding among American academics recently. They see us as having lost a major foothold in microprocessor technology to the rest of the world because we didn't cooperate. We competed, rather,

with ourselves. I think now there is a marvelous spirit of cooperation among American biotechnologists. I met recently with the director of the Center for Innovative Technology in Virginia. We talked about collaboration in biotechnology between Maryland and Virginia. I truly see this as a collaborative effort.

Mr. SCHEUER. Very encouraging. This has been an excellent panel and I have enjoyed it very much, Mr. Chairman.

Mr. McMILLEN. Thank you, Mr. Chairman.

Just one final comment. When Mayor Schmoke testified, he talked about a \$150 million marine biotechnology business relating to the products. I think that he was referring to the current, direct products annually. Dr. Hooker, you talked about \$15 billion.

Mr. HOOKER. Yes.

Mr. McMILLEN. Is that an end-of-the-century projection?

Mr. HOOKER. The projection was in a MITI publication just last month. It is a projection not for biotechnology products but for marine biotechnology products, and is an end-of-the-century projection, \$15.4 billion a year.

Mr. McMILLEN. So we are talking about an industry at \$150 million going to tenfold that, or actually a hundredfold that, in a matter of 10 or so years?

Mr. HOOKER. If MITI is correct. I think it is probably exaggerated but, as I say, if it is 100 percent exaggerated it is still a lot of money.

Mr. McMILLEN. Let's close on this question here, and that is, can our country afford not to support a facility such as the Christopher Columbus Center, and what would that mean in terms of garnering a significant share of that marine biotechnology business in the future?

Mr. HOOKER. Because this is the leading center in the country in marine biotechnology, it is the place to put our chips to bet on the future of marine biotechnology at the present. There may later be other areas where the country should invest, and I certainly don't think that a \$50 million investment by the U.S. is enough in marine biotechnology. I think it should be orders of magnitude greater than that, but I think this is the place to begin. As the Mayor said so aptly, this is our Cape Canaveral opportunity in marine biotechnology, and biotechnology is going to be the dominant technology of the next century. There is no doubt about that, especially since Mason jar fusion seems to have fallen by the wayside, so this is the frontier for us and I think we can't afford not to take advantage of it.

Mr. McMILLEN. Dr. Singleton?

Mr. SINGLETON. I believe that it would not be wise, certainly, if we did not do this. To give you an example of the potential, seaweeds, which many people kick aside on the strand, the edible seaweeds in Japan and China represent a \$1.2 billion market today. Biochemical compounds from marine algae, microalgae from seaweed, represent a market between \$500 million and \$1 billion right now.

In fact, I would venture to guess, to state without any hesitation that everyone in this room has had contact with a product from marine algae today. It is found in most dairy products as a stabilizer and emulsifier. It is found in toothpaste. It is found, 60 percent

of the world's production of one type of algenate, biochemical algenate, is used in the textile and paper industries. If we do not move now to take advantage of the opportunity, we are forfeiting it to other countries.

Mr. McMILLEN. When you speak about industrial policy, this seems to be the area where our country ought to be heading, where Maryland, the State of Maryland, has tremendous synergism in this area. There probably are only a handful of States that have all the array of resources that Maryland has. To me, when you think of a national direction, to try and coordinate with each State and to develop their best is really the kind of industrial policy we ought to be talking about, not picking and choosing individual winners or individual companies but helping each State develop their own economies of scale and efficiencies based on their own natural resources.

Thank you for your very enlightening testimony, and we look forward to working with you on this thing.

Mr. SCHEUER. You have been an outstandingly fine panel.

Mr. McMILLEN. The fifth and last panel will focus particularly on the issue of aquaculture. Bradley Powers is the aquaculture coordinator for the Maryland Department of Agriculture. Larry Simns is the president of the Maryland Watermen's Association. Welcome, Larry. We appreciate your coming here today. Donald Webster is the area agent for the Sea Grant Extension Program, University of Maryland.

As we have done with our other witnesses, for the sake of time if you would summarize—I might add for the record that Mr. Webster just gave me 1 million Maryland oysters in this vial, and believe me, that could feed me for a long time—for the sake of time, if you would summarize your testimony, we will include it in the record and look forward to asking some questions.

Mr. Powers?

STATEMENT OF MR. BRADLEY H. POWERS, AQUACULTURE COORDINATOR, MARYLAND DEPARTMENT OF AGRICULTURE

Mr. POWERS. Good afternoon, gentlemen. I am Brad Powers, Maryland's aquaculture coordinator. You have my written testimony for the record, which provides a brief overview of the manner in which Maryland's aquaculture industry is developing. I will highlight some of those comments, but today I plan to stress the importance of not only the Christopher Columbus Center to aquaculture but also the need for USDA funding for a regional aquaculture center for the Mid-Atlantic States.

Although from a State government viewpoint aquaculture is just a fledgling industry in Maryland, it has actually been an important part of our economy for nearly 100 years. Shortly after the turn of the century, Frederick County was the site of almost 50 farms growing goldfish. Today the single largest finfish producer in the State is Hunting Creek Fisheries, a goldfish and koi farm with 110 ponds and numerous indoor flow-through and recirculating systems on 75 acres, located just north of Frederick near Camp David. This operation, which relies heavily on exports to Canada and Europe, has been in continuous operation for 65 years. Although we have

just begun to recognize the potential of aquaculture worldwide, Maryland is blessed with having experienced leaders in the industry such as this.

Aquaculture, in its simplest terms, is the business of farming aquatic plants and animals. That definition, although short and to the point, is full of meaning. First, aquaculture is a business but, more importantly, a farming business, and it includes plants, as well as animals, that are grown in water. Nearly everything we read or hear about aquaculture involves finfish and shellfish, but plants are finding their own place in this business in other parts of the world and they will in Maryland, too.

As is generally true with Maryland's farming practices, aquaculture production is developing in a widely diversified manner. Even though most of our industry is less than five years old, we have people raising crawfish, catfish, trout, bait fish, ornamental fish, game fish, aquatic plants, oysters, clams, tilapia, and several experimenting with striped bass, hybrid striped bass, and eels. The marketing techniques developed for these products will undoubtedly be as diversified as the products themselves.

The Christopher Columbus Center, through its close working relationship with the Center of Marine Biotechnology, will, I am sure, be on the cutting edge of genetics, disease, and environmental issues related not only to aquaculture but the seafood industry as a whole. A great deal of effort has already been focused on the future of the Chesapeake Bay and associated coastal waters. This effort must continue, not just for the benefit of commercial fishermen who are so important to the Chesapeake region's economy, but for all Americans. Our Bay is a national resource as well as a natural resource, and it is one of a kind. Larry Simns, president of the Maryland Watermen's Association, who is on the panel today, will expand on the watermen's viewpoint in just a moment.

In addition to the high-tech type of work that can be spearheaded by the Christopher Columbus Center, we also need greater emphasis on very practical applied research which can address species selection, breeding, feeding, engineering, economic and marketing concerns that face aqua farmers on a daily basis. There are currently five regional aquaculture research centers funded by USDA in operation. Maryland is a member of the northeast region headquartered in Massachusetts. On the other hand, our primary partner in the Chesapeake Bay, Virginia, draws its support from the center in Mississippi.

The interests of Mid-Atlantic aqua farmers may not always follow those of either warm water or cold water States. If aquaculture is to utilize the tremendous resource of the Nation's largest estuary without adversely impacting it, greater emphasis must be given to funding research for the region. Maryland, Virginia, Delaware, Pennsylvania, and West Virginia comprise this Chesapeake region.

Although we continue to refer to the regional aquaculture centers as though they are physical plants of mortar and brick, they are in reality programs, not buildings. Funding for the centers from USDA comes about as a result of the Federal Aquaculture Act of 1980. Those of us involved in developing the future of aquaculture as a viable industry fail to understand why a regional pro-

gram was not established for the States which impact the Chesapeake Bay. The uniqueness of this estuary and its vital importance to the United States as a whole should be sufficient cause to consider a Mid-Atlantic regional aquaculture center.

I will not attempt to provide you with a summary of research projects now underway which could be better coordinated for the benefit of the States in the Chesapeake region. Don Webster from the University of Maryland, who is also on the panel today, is much better qualified to do that.

Your support of a Mid-Atlantic regional aquaculture center for Maryland, Virginia, Delaware, West Virginia, and Pennsylvania, as well as the Christopher Columbus Center, will certainly provide the positive direction needed for aquaculture to be a major industry for all of us.

Thank you.

[The prepared statement of Mr. Powers follows:]

TESTIMONY PRESENTED BEFORE
THE SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT
ON
THE FUTURE APPLICATION OF AQUACULTURE AND MARINE BIOTECHNOLOGY TO THE
NATION'S ESTUARIES AND COASTAL WATERS
MAY 15, 1989

Good afternoon, Mr. Chairman and members of the Committee. I'm Brad Powers, Maryland's Aquaculture Coordinator. Although, from a state government viewpoint, aquaculture is just a fledgling industry in Maryland,¹ it has actually been an important part of our economy for nearly 100 years. Shortly after the turn of the century, Frederick County was the site of almost 50 farms growing goldfish. Today, the single largest finfish producer in the state is Hunting Creek Fisheries, a goldfish and koi farm with 110 ponds and numerous indoor flow-through and recirculating systems on 75 acres, located just north of Frederick in Thurmont. This operation, which relies heavily on exports to Canada and Europe, has been in continuous operation for 65 years. Although we have just begun to recognize the potential of aquaculture worldwide, Maryland is blessed with having experienced leaders in the industry such as this.

Aquaculture, in its simplest terms, is the business of farming aquatic plants and animals. That definition, although short and to the point, is full of meaning. First, aquaculture is a business, but more importantly, a farming business. And it includes plants as well as animals that are grown in water. Nearly everything we read or hear about aquaculture centers around finfish and shellfish but plants are finding their own place in this business in other parts of the world and they will in Maryland, too.

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Most of the state's formalized efforts toward aquaculture have taken place since the spring of 1987 when Governor Schaefer appointed the Aquaculture Task Force which developed the action plan that guides us today. However, in the early 1980's, an ad-hoc committee comprised of state agencies like Agriculture, Natural Resources, Health and Mental Hygiene and the University of Maryland, along with private sector representatives including the Watermen's Association and Maryland Farm Bureau, presented a very short paper in support of aquaculture entitled "Perspectives of Maryland Aquaculture". But not until aquaculture was included in Governor Schaefer's position paper on agriculture did the effort gain momentum. As a result of the Task Force Report, the General Assembly passed the first law aimed directly at the development of aquaculture as an industry in Maryland. This first legislation, although not a fix-all, set the stage for future efforts by first recognizing aquaculture as an agricultural enterprise and, secondly, establishing the Maryland Department of Agriculture as the lead agency for marketing and overall coordination, the Department of Natural Resources as the lead for enforcement, and the University of Maryland in the lead role for research, education and extension. Additionally, it also began the process through which endangered species, such as striped bass, could be raised in aquaculture.

In the months that followed the 1988 legislative session, a great deal happened. With the appointment of an Aquaculture Coordinator, a new aquaculture office was established within the Department of Agriculture. An eighteen-member advisory committee was formed and work immediately began on proposals for additional legislation for both tidal and non-tidal aquaculture.

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Hammering out language acceptable to such diverse groups as are represented on the advisory committee is an interesting exercise in group dynamics. The committee includes representatives from the aquaculture industry, watermen, traditional agriculture, seafood processors, seafood wholesalers, retailers and consumers, the scientific community, pleasure boaters and sport fishermen, tidal fisheries, the General Assembly, MDA, DNR, and finally, the University of Maryland. Needless to say, the group rarely all agreed on any subject at first but, when the final draft of a proposal was ready, it was something they could all not only live with, but also support.

As information about aquaculture reached the popular press, the aquaculture office and offices at the University and DNR began receiving a multitude of requests for assistance in getting into this new industry. During the first ten months of the aquaculture office's existence, hardly a day has passed without at least ten to twelve requests for information.

Maryland now has over 40 farmers growing crawfish, several growing catfish, trout, baitfish, ornamental fish, gamefish, aquatic plants, oysters and clams. Along with these are numerous others experimenting with striped bass and hybrid striped bass, a warm water fish known as tilapia, eels and even some with an interest in trying salmon. We have ponds being built, existing ponds being retrofitted, cages constructed to grow fish in farm ponds without any changes, net pens floated in former gravel pits, raceways growing trout in buildings where mushrooms once grew, oysters grown in floating trays in one-third the time it takes on a traditional oyster bar, hard clams produced in containers, a tobacco barn being converted to indoor culture of catfish, and even a former sewage

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holding pond being considered as an aquaculture training facility where effluent from a sewage treatment plant is so clean it might be used to grow fish.

To help support this dynamic industry, the aquaculture office has assisted with the organization of the Maryland Aquaculture Association to serve as the voice of the industry. The Association now has 14 directors from seven regions of the state and is already beginning to plan its first annual meeting in conjunction with a workshop this fall.

Back in 1983, when the ad-hoc aquaculture committee issued its first report, several constraints to the future of this new industry were identified. The first and foremost was legal or regulatory concerns. Bills just recently passed by the 1989 General Assembly have begun to address the fact that aquaculture is, indeed, an agricultural activity and not part of the wild fishery. There remains a great deal of concern about how aquaculture should develop in the open waters of the Bay and its tributaries. To address this to some degree, DNR and the University are working with watermen to demonstrate net pen culture of native striped bass. A great deal must be learned as to not only how to grow fish in this environment but also the environmental impact of such practices. Meanwhile, non-tidal or land-based aquaculture received a helping hand from the Legislature with the passage of a bill that, among other things, provides for the purchase of striped bass and hybrid striped bass fingerlings from out-of-state sources starting June 1, 1989 and then the sale of these fish from aquaculture facilities as of January 1, 1990.

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Additionally, it was recognized that fish grown in aquaculture were not threatened or endangered species and, furthermore, regulations for wild species do not apply to those grown in non-tidal aquaculture. Although these measures may seem to be common sense, they are actually landmark decisions not yet addressed by most states.

Maryland may not be a leader in fish production but it is fast becoming a model for industry organization and support.

The recent opening of the new facilities for the Center of Marine Biotechnology and the development of the Christopher Columbus Center are two more indications of the type of support that will make Maryland an important hub of aquacultural activities. However, the demand for technology, born of research applicable to not only Maryland but the other states that influence the future of the Chesapeake Bay, is mounting daily. Maryland is currently a part of the federal regional aquaculture center based in Massachusetts. On the other hand, our primary partner with the Bay, Virginia, draws its support from the center in Mississippi. The interests of Mid-Atlantic aquafarmers may not always follow those of either warm water or cold water states. If aquaculture is to utilize the tremendous resource in the nation's largest estuary without adversely impacting it, greater emphasis must be given to funding research for the region. Maryland, Virginia, Delaware, Pennsylvania, and West Virginia comprise this Chesapeake Region. Unlike shrimp farming in the Gulf region, the vast expanses of catfish ponds in the Delta and salmon production in the New England area, the Chesapeake or Mid-Atlantic region will undoubtedly see a wide diversity of cultural practices. As has been seen in vegetable production, the proximity to vast populations dictate

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this diversity. This region, in addition to supporting traditional watermen who become aquafarmers of the Bay, can also be the same area that sees the development of direct-to-consumer markets for farm-raised fish, as well as a rebirth of wholesale and retail seafood distribution networks. A federal regional aquaculture center can provide the type of program, shared by the participating states, that will not only address the uniqueness of the Mid-Atlantic growing region but also the unique opportunities for market research and development.

The Departments of Agriculture in Virginia, Delaware and Maryland have already embarked on a joint domestic and international marketing program unlike any other in the United States. We would now like to expand that effort to aquaculture with your assistance and guidance through the development of a Chesapeake Regional Aquaculture Center.

Mr. McMILLEN. Thank you very much, Mr. Powers.
Our next witness is Mr. Simns, head of the Watermen's Association in Maryland. We thank you for joining us.

**STATEMENT OF MR. LARRY SIMNS, PRESIDENT, MARYLAND
WATERMEN'S ASSOCIATION**

Mr. SIMNS. Thank you for the opportunity to be here. As you probably know, I represent the commercial watermen of the State of Maryland. After hearing the Governor's testimony and reading some of the newspapers, you probably wonder why I would be here supporting the aquaculture center. Let me give you a little bit of background on the watermen and the aquaculture projects going on in Maryland.

The watermen have been perceived to be opposed to aquaculture products mainly because, in the zeal of the people promoting aquaculture, they went all out with it in mind that one was going to replace the other. In order to maintain and save our livelihood, we just had to oppose proposals that were so broad and far-reaching. In other words, that is how everyone came out with the perception we were against aquaculture. Indeed, that is not the fact because many of our watermen are very interested in aquaculture. They just do not want to sacrifice the commercial interests for the aquaculture interests, and there is a fine line there that you have to be careful of.

One thing that really needs to be done, especially in the Chesapeake Bay area, is planning. Like any other business, if you don't plan well, you are going to have crises and disasters and probably in the end, financial disaster. The problem with that is, you say, why would the watermen worry about it if aquaculturists have a financial disaster? We are not so worried about somebody having a financial disaster as we are about the disasters that would be left in the wake of their disaster. If the perception is taken that we replace the commercial fishery with aquaculture, the damage that could be done with that thinking is, if the aquaculture didn't work, then you have also destroyed your commercial fishery, so then you wind up with none.

Our position is that we can have both and they can complement each other in the marketplace. They can sustain the markets and have an equal market or a long-range market plan where everybody will know that they have a guaranteed product. There are times of the year that aquaculture can't put their product on the market, and there are times of the year that the commercial fishery can't put their product on the market. Hopefully, working hand-in-hand, we can make that supply come along as an equal thing, so that you have a steady supply.

So we certainly do support an aquaculture center here in Maryland for a number of reasons. One thing, as a commercial fisherman or a waterman, even if we weren't to get involved in aquaculture, we feel like if you keep in mind that there is a commercial fishery that is very important, that the research that you are going to be doing is also going to help that commercial fishery. We have lots of parasites, diseases, the Bay degradation and all those different things that can benefit by the research that can be done in

such a center, so we do support it. We just want to make it very clear that you have to be very careful, when you are promoting aquaculture, that you do not substitute one for the other.

There is one other thing that we have to be very careful of, and I think lots of people take the perception that once you have aquaculture, that you don't have to worry about the pollution, and that is something that we really have to worry about, even with aquaculture. Even if you are just growing it on land where you have controlled conditions, you will never, ever be able to replace what Mother Nature can do, no matter how great we do in aquaculture. Mother Nature, if you keep the system clean, can produce millions of times more fish and oysters and crabs at a cheaper price than aquaculture can. But under our present conditions, with the Bay degradation or all waterway degradation and with the need for seafood, then we also recognize that the commercial fishery is not going to supply that need.

What we have to look at now is the imports coming from other countries to this country. We shouldn't have to import seafood in this country at all. We should be exporting, so that is why we support the center, because the more we know about raising the fish and the oysters, the more we can protect the ones in the wild, and then the commercial fishermen and the aquaculturists can survive, and we can produce enough seafood to feed the world.

It is very, very important that we work together on this. I predict that in the future, that seafood is going to be the major source of food for the whole world, and I think by having this center that we are putting a foot forward where we should.

Thank you.

[The prepared statement of Mr. Simns follows:]



The Maryland Watermen's Association, Inc.

TESTIMONY PRESENTED BY
LARRY SIMNS, PRESIDENT
Maryland Watermen's Association

Before
The Sub-Committee On
Natural Resources, Agriculture Research and Environment
May 15, 1989
Baltimore, Maryland

For the most part you, as a group, are probably surprised that the President of the Maryland Watermen's Association would be here today to testify in favor of developing an aquaculture center in the Mid-Atlantic Region.

There is a perception among aquaculturists, government leaders and industry people that commercial watermen are dead set against any type of aquaculture enterprise in the State of Maryland. I want to make it clear just what the stand of the Maryland Watermen's Association is pertaining to aquaculture development.

First, understand that the commercial watermen do not have a negative mind-set against aquaculture and we are not dealing with it on an emotional level as some people seem to think. There are many watermen who are interested in developing aquaculture areas, along with their commercial harvesting enterprises.

We have stated before the state legislature and I will again state it here that the watermen are not opposed to aquaculture activity. We have been forced to take an opposition stand because those who have been promoting aquaculture in the State have gone forward wide open, and seem to have the idea that one industry must be sacrificed for another. Sacrificing one industry for another is not necessary but because of the fast-paced direction of those pursuing aquaculture, commercial watermen have had to take an opposing view in order to slow down the process and gain some sense

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of organization.

Watermen of the Chesapeake Bay have an insight to what is practical, what is workable and what is not possible from their long years of working and observing the Bay and its many hazards, cycles, and its ability to rebound from disasters. With this vast knowledge of the watermen who work every part of the rivers, tributaries and the Bay, itself, and the knowledge handed down to them from their parents and grandparents, watermen have the ability to be able to predict with some degree of accuracy the success or failure of Bay related projects.

Therefore, the watermen recognize that lots of damage can be done by making snap decisions on the future of aquaculture. We know that in any business enterprise that long range planning has to be done - caution should be taken when you are changing or developing a major industry. Aquaculture can either cripple the commercial fishery or help it prosper and grow. The watermen, using that knowledge, have been instrumental in getting the Maryland legislature to slow down the pace enough so that some long-range planning can be done without sacrificing the commercial industry to the aquaculture industry.

The Maryland Watermen's Association's position is that aquaculture is a growing industry and a much needed industry and we support it. We feel that the growing consumption of seafood products can be taken care of in this country without the need to import such large quantities of seafood from foreign countries. We also recognize that the natural stocks will not continue to supply that need, especially in view of the pollutions and degradations of the waterways due to natural or man-made disasters and the growth and population problems.

We must never lose sight of the fact that if water quality is maintained in the natural system, nature can produce millions of times more product than aquaculture will every be able to produce and at a price affordable to the consumer.

I do want to make it very clear that there need not be a sacrifice of the commercial fishery in order to have an aquaculture program. The two should

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go hand in hand and compliment each other and working together fill the voids that will occur in supplying the market with good seafood products. Together they can maintain a steady supply of product. Together they will help build more and better markets. Together they will stabilize the industry so that everyone involved will be able to make a living at either commercial fishing or aquaculture, or both. Alone, neither will survive or fill the consumer needs.

There is a need to be very careful and to do detailed planning so that aquaculture will not degrade or pollute the natural stocks. Aquaculture should not interfere with or take away productive areas of commercial fishermen.

With careful planning and careful study good areas that are suitable for aquaculture, both on land and in the open water, can be developed that will not interfere with the commercial fishermen or the species they harvest.

There should be indepth studies made of areas that are to be considered for aquaculture enterprises. These studies should consist of water quality, type of bottom, tides and currents, ice conditions during winter months, salinities, and careful analysis of what diseases or parasites have been noted in the area in the past. Also, commercial fishing activities should be noted, along with recreational boating traffic, and, what species are in abundance and what affect the aquaculture will have on them. This study will help to prevent aquaculturists from investing large sums of money on a trial and error basis, or learning as you go, and protect their investment by having as much knowledge as is available. This would also protect the commercial fishing activities for the native species already established in the area.

Without good planning and study you can severely cripple the commercial harvests without meaningful gains in the aquaculture community.

Bear in mind that to completely ignore the natural stocks that we have in any of our systems with the thought that aquaculture will replace them will be a foolish and costly move for any government to make.

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The Maryland Watermen's Association feels aquaculture is developing so fast that it is important to have more aquaculture centers throughout the country. Therefore, the commercial watermen think it is essential to have an aquaculture center in the Mid-Atlantic Region and we feel strongly that Chesapeake Bay should be the focal point. Maryland is well suited because there is access to all different salinities within a short distance and there are many species that are adaptable to aquaculture. Maryland is centrally located in the Mid-Atlantic area, representing the broad range of climate found in this geographic region.

The aquaculture center could help aquaculture and the commercial fishery with research directed at disease and parasites that affect the wild stock which will also affect aquaculture stock and we could learn more about what produces harmful effects on stock reproduction.

It is most important that any work that is performed through the aquaculture center be applied equally to aquaculture stocks and wild stocks for the betterment of both industries.

I would hope that everyone supporting the aquaculture center concept will also support the commercial fishery of this country because these industries will be the most important source of food in the future.

Mr. McMILLEN. Thank you, Larry, for your comments about how to balance the interests of the watermen and the aquaculturists as we go forward.

Mr. Webster?

STATEMENT OF MR. DONALD W. WEBSTER, AREA AGENT, SEA GRANT EXTENSION PROGRAM, UNIVERSITY OF MARYLAND

Mr. WEBSTER. Thank you. I would feel a little bit more comfortable being over on the Eastern Shore today moving oyster shell or being out on one of the ponds, but I thank you for the opportunity to come here.

The folders I gave to you have some of the materials that we have produced out of the University of Maryland in the past few years in support of our aquaculture programs, including some of the conference materials that we have had and some of the things that we have planned, and the oyster larvae that I gave you are indeed 1 million oyster larvae. That is just to help you see some of the things that we are doing in working with our oyster growers, providing larvae to them, teaching them ways to help produce oysters that are a little bit better.

I have been working in aquaculture now for about 10 or 11 years, in programs with the university. We really have seen a need for aquaculture in Maryland to come along. I was kind of interested in the comment the gentleman made before about the Arabs and the Israelis working together. Perhaps there is hope for the Eastern Shore yet.

[Laughter.]

I think we are not very far apart. I know the reason we got into aquaculture originally was because we realized we needed to increase seafood production in the State of Maryland. Certainly on the university's part there was never any intention to replace one with the other. We want to see them complement each other. We want to see a good public fishery and a good private fishery. We think there are markets for both. We know there are markets for both.

The reasons for aquaculture? Well, in Maryland we have seen a steady downward spiral of harvests from the natural stocks that have caused us to fall into kind of an also-ran position in the seafood industry. The Governor of the State was here before. Governor Schaefer has probably done more in three years than all the rest of the Governors in this State in the last century, because he understands what aquaculture is. It is economic development for our rural areas. Far from acting too quickly, as some people are saying, he is really trying to make up for a lot of lost time.

We have had some very good legislators here in the State who have had the foresight to push through several very important aquaculture bills, and we have a good infrastructure of existing fish and shellfish farmers here in Maryland that have really come forward in the past three years, when the Governor came in and demanded a State aquaculture plan in something on the order of 90 days. You don't get that. It takes 2 and 3 years to do it, but he got it in 90 days and it was a good one. A lot of those same people

now serve on the State Aquaculture Advisory Committee and they are also officers and members of the new Aquaculture Association.

The oyster larvae that you have there, one of the things we have been doing is trying to adapt systems that are already in place. What has revolutionized the oyster industry in the Pacific Northwest is a technique known as remote setting, where hatcheries produce larvae rather than spat.

Mr. SCHEUER. Rather than what?

Mr. WEBSTER. Rather than spat, small oysters. We have been working with people. We started a small group in one county about 6 or 7 years ago. We now have demonstration projects going in 10 different counties.

The diseases, Dermo and MSX, continue to present great problems not only for Maryland but the entire eastern oyster industry. The idea that any of the natural oyster populations are going to come back on their own, now that those diseases have made inroads in many of the traditional producing areas, that is not going to happen. If that were the case, New Jersey would have come back as a dominant power in the oyster industry many years ago, and they did not. They are going to need to put oysters back in these areas, and certainly aquaculture is one way that that can be done. And the more oysters that go overboard into the Bay, I think Larry would certainly agree with me, the more potential there is for natural spawning to occur and keep our natural oysters going.

Looking at disease management, in the short term we may have to look at management options such as adapting ideas from other areas, like we have done with remote setting; trying to grow oysters to market size, get them up, produce a market oyster in two years, before the diseases are able to kill them. There are many intermediate-term programs such as breeding selection, as Rutgers has done with MSX. They have demonstrably come up with an oyster that has more resistance and is better able to cope with MSX. It doesn't do well against Dermo, however, but this is something else we would have to look at.

These are things that an aquaculture center could be looking at, management-type options. Long-term programs in biotechnology—great. I mean, hopefully that is the way things are going in the future. As Brad said, there is a lot of interest in Maryland with the production of fish, and certainly catfish and hybrid striped bass, I think they are the big ones here in the State.

When I first started working on aquaculture programs about 10 years ago with the university, we held a single conference in 1979. We were expecting about 40 people to show up—it was on oysters—and we had 150 people show up, and they demanded that it become an annual affair, and we have kept that up. Next month we will be holding our 11th annual conference. It is now a joint Maryland-Virginia affair, where it is sponsored and planned by the University of Maryland, Virginia State, Virginia Tech, William & Mary, the University of the District of Columbia. We have a long record, a long track record of working across State lines with our neighboring States of Delaware and Virginia. I have been involved in about a dozen other programs during the course of the year on various types of aquaculture subjects.

We have a major hybrid striped bass aquaculture facility, funded by USDA, up on the Eastern Shore of Maryland. We will be holding programs there to train people on how to raise these fish. We have worked with Virginia Tech on studies to market hybrid striped bass, to look at the yields, to look at shelf-life studies, to look at prices in the marketplace, to do background heavy metal and pesticide analysis on them. These are all areas that the University of Maryland has put money into, has committed positions to over the years. We now have a good extension program with fin-fish and aquaculture specialists, agents in several areas, and this could grow in the future.

Brad hit on something. We are the southern limit of the Northeast center, in Maryland, the aquaculture center. Virginia is the northernmost limit of the southern region. That has created problems. We would very much like to see a Mid-Atlantic aquaculture center. I believe that it would be up and going probably faster than any of the others, since they have had to kind of feel their way, and we do have an awful lot of background and work in dealing with these other States on aquaculture programs. I support it and I hope we can get it. I fully support any of the efforts that would be made in order to establish one here in Maryland.

[The prepared statement of Mr. Webster follows:]

TESTIMONY OF DONALD WEBSTER
 UNIVERSITY OF MARYLAND
 COOPERATIVE EXTENSION SERVICE
 MAY 15, 1989
 BALTIMORE, MARYLAND

Last week the Cooperative Extension Service celebrated the 75th anniversary of the signing of the Smith-Lever Act which formalized Extension as one of the three legs of the Land Grant agricultural research and education system. It is no accident that the United States is a World leader in food production. We did it in agriculture, we can do it in aquaculture.

THE POTENTIAL

I have been involved in aquaculture for about eleven years now. I had been in the seafood industry and moved to Maryland in 1974 to work for the University of Maryland Cooperative Extension Service on marine programs. In working with scientists it became painfully obvious that something was wrong in the Chesapeake Bay. Natural reproduction was poor or, at best, highly erratic and overharvesting was normal. Populations were declining and it was clear that the seafood industry was going to have to change old ways of thinking and doing business in the future--if, that is, it was going to have a future.

While scientists were being asked to find out WHY the natural populations weren't reproducing properly, those of us in Extension posed the question differently. "HOW", we asked, "can we increase seafood production?"

Aquaculture provided a way for the industry to continue and compete in the modern world marketplace. I believe that it holds a great deal of promise for food production in this region and I support those efforts and activities which will allow it to expand and increase our seafood production.

Although we in Maryland have experienced 150 years of resistance to change in the oyster industry and many decades of impassioned fighting against any degree of private cultivation of seafood we have, in the past few years, seen several factors in our state which have made change possible if not inevitable.

1. A steady downward spiral of harvests from natural stocks which have caused Maryland to fall from a position of relative prominence to one of a distant "also ran" in the seafood industry.
2. A Governor who readily grasped the concept of aquaculture as economic development. Indeed it has been Governor Schaefer who has been the catalyst for change. Far from acting too quickly, it is obvious that he has been trying to make up for many years of lost opportunity.

3. Legislators who have had the foresight and courage to submit several important aquaculture bills and see them through, even against considerable and personal odds.
4. An existing infrastructure of finfish and shellfish farmers who have been willing to come out of the trenches and do battle for their industry. Many of these individuals helped develop our State Aquaculture Plan and now serve as members of the Aquaculture Advisory Committee and as officers and members of the new Maryland Aquaculture Association.

Maryland has passed several major pieces of aquaculture legislation in the past two years which are helping to give us the tools needed in order to develop the industry. This years major bill will allow the important Hybrid Striped Bass (HSB) industry to develop. While the future looks bright we are not without problems in several areas. Strong programs in research, education, and extension will make the significant difference in the industry's development.

THE PROBLEMS

In the oyster industry, social and political problems continue to be the most persistent but the premise that an increase in private oyster production will bring an irreparable change to the watermen's "way of life" is being challenged. The question is becoming, "How much longer will taxpayers be willing to subsidize a 'way of life' for people who just don't want to change?"

Technical problems which need solutions involve such areas as the need to produce large volumes of reasonably priced seed oysters which will survive in sufficient quantities in order to assure the grower a profitable crop. Hatchery technology exists in Maryland in the form of two public sector and three private sector hatcheries. One of their most pressing needs is for ways to decrease larval mortality to more acceptable levels.

The method known as "remote setting", the production of spat by the grower rather than the hatchery operator, has revolutionized the West Coast oyster industry. We have been working with an ever increasing number of Maryland growers to adapt the practice to this area. Several have now constructed their own production facilities. Other problems which need to be more fully addressed are the uses of innovative cultch materials in bottom stabilization and methods of rehabilitating existing shell deposits as an alternative to expensive overshelling with our finite fossil shell resource.

The diseases known as Dermo and MSX continue to present great problems for the entire Eastern oyster industry. The idea that the natural oyster populations will come back on their own and support any major commercial fishery again is extremely naive and contraindicated by three decades of experience here in the Mid Atlantic. Government and politics were largely responsible

for the spread of the diseases in Maryland and the problems will now have to be attacked on several fronts. These alternatives will require aquacultural methods for implementation.

1. In the short term, management options may be the most useful. We can adapt ideas from other areas to grow oysters to market size before they are killed; track salinity patterns and move animals into areas which will support populations, and; investigate growing a higher value oyster for the half shell trade which can provide increased return for increased production costs.
2. Intermediate term programs such as breeding and selection may be able to produce hardier and more disease resistant stocks; hybrids and polyploids may produce animals which may not be as affected by diseases although this may, and probably will, require changes or modifications in current laws even if they are found to be environmentally safe.
3. Long term programs in biotechnology and genetic engineering may produce animals which are disease resistant although it is recognized that problems will exist with introducing these animals into the environment also.

Production of fish such as catfish and Hybrid Striped Bass (HSB) has generated considerable interest in the recent years in the Mid Atlantic region and I predict that our states will become major producers in this market. However, I wish to stress that HSB is a pioneer industry and will require attention to research in several areas.

1. Land and construction costs are high and may remain a major obstacle for entry level fish farmers.
2. Soils and their application for pond construction may make some areas unsuitable or costly for pond culture but offer opportunities for open water pen culture.
3. Water quantity, quality, and allocation may see pressure to protect shallower aquifers which will raise drilling and pumping costs. Regulated water allocation may require research in water re-use systems in order to minimize costs.
4. Lack of trained culturists will provide opportunities for expanding existing Extension educational programs and activities.
5. Domestication of brood stock will be a problem with newer fish culture industries. Public policy questions will focus on access to natural stocks for use as brood fish until domesticated brood stocks are a reality.

6. Applicability of various crosses and stocks will help us find out which fish can provide the features and qualities desirable in aquaculture.
7. Feeds and nutrition of many cultured animals provide opportunities to find ways to make them grow faster and better.
8. Disease diagnosis and control agents provides an urgent need for development and registration of various therapeutants while continuing to be a vexing problem for fish farmers.
9. Processing, marketing, and distribution offers exciting opportunities. People are becoming more aware of the quality of their food and the nutritional components what they eat. Aquaculture can provide people with assurance as to where their food came from and how it was produced. Our existing seafood plants in places like Crisfield have had one very big problem for some time--lack of continuous product to process. The poultry industry sees bright possibilities for diversifying their product lines through aquaculture. It is not accidental that many of the people I have met in aquaculture have strong backgrounds in the poultry industry.
10. Legal and regulatory problems will continue to crop up but will, in all likelihood, be addressed by ever growing producers working through their representative associations.

I consider these to be some of the major problems and issues facing aquaculture but I do not believe that they are insurmountable. Indeed I think that many of them provide exciting opportunities for our food industry and public sector agencies and institutions. I would not have put as many years into aquaculture programs as I have if I thought otherwise.

THE OPPORTUNITIES

When I first started working on aquaculture programs we had a small staff and very few actual producers in Maryland. Today that has changed considerably. We began our educational efforts in 1979 with a single conference. We expected 40 to attend and over 150 showed up. Next month we will hold our 11th Annual Conference. It is now sponsored by Maryland and Virginia and is planned by representatives of the University of Maryland, Virginia Tech, Virginia State University, the College of William & Mary, the University of the District of Columbia, and the Maryland and Virginia Departments of Agriculture.

In addition to this conference I am involved in more than a dozen county or regional programs during the year for people interested in pond management, fish production, aquatic vegetation control, crab shedding, oyster aquaculture, and crawfish production. We will soon be holding a joint program with the University of Delaware in cage and net pen construction.

We have a major Hybrid Striped Bass (HSB) aquaculture demonstration facility located on the Eastern Shore of Maryland in a cooperative venture between the USDA, Walnut Point Farm, and the University. We will be holding programs there to train fish farmers in HSB production techniques.

We have cooperated in HSB studies with Virginia Tech on marketing, consumer surveys, taste tests, processing yield and produce shelf life, flesh composition, and background heavy metal and pesticide analysis of HSB versus natural striped bass. We are working with them on a more in depth study for the future so that our industry will have the best possible information on which to base investment and management decisions.

The University of Maryland Cooperative Extension Service (MCES) has included aquaculture as one of its major issues and has gone to great lengths to add new agents and specialists to its staff in order to address the "Profitability of Aquaculture and the Marine Industries". Other subdivisions of the UM such as the Horn Point Lab and the Sea Grant College have continued to make significant commitments to the development of this industry.

There are currently more than ten catfish production operations either planned or operating in Maryland and over a dozen HSB facilities which are, at present, demonstrations just waiting for the legalization of sale to occur in order to get into commercial production. We have producers of trout, goldfish, and many other species and the potential is there for other states in the region to do the same.

The demand for applied aquacultural information has increased vastly over the years and MCES has responded by producing a series of informational publications addressing specific topics. These will be expanded in the future. Several are joint publications with nearby states.

While we share programs, activities, publications, and one of the most unique geographical features in the United States, the Chesapeake Bay, with our neighbors we are strangely separated when it comes to the current Regional Aquaculture Centers. Maryland is at the southern fringe of the Northeast Center, located in Massachusetts, while Virginia is at the northern limit of the Southern Center, which is in Mississippi and which deals almost exclusively with the important catfish industry. A Mid Atlantic Center would provide a means to more logically direct funds toward the solution of our common species and concerns.

Knowing and working with many of the individuals in the public and private sectors dealing with aquaculture in the Mid Atlantic, I believe that it would be one of the most active and productive centers in the system. I fully support the efforts in which you are engaged in order to establish it.

Mr. McMILLEN. Thank you very much for your comments in relation to aquaculture. I am sitting here listening and reading your testimony, and I can't help but see the promise of this industry when you look at the declining production of oysters, for instance: 1 million bushels today compared to 2.5 million bushels in 1970; the fact that aquaculture is growing at about 20 percent per annum and that you see great promise in this industry; the idea that aquaculture can produce 500 to 1,000 bushels of oysters per acre compared to, again, natural production rates of maybe 4 bushels per acre.

The concern that I have heard here and that I think Larry and others have pointed out is the risk to the watermen, to the recreational boaters, of rushing headlong into aquaculture development. Obviously if we get a marine biotech center here in Baltimore, that is going to be great impetus for this industry in Maryland, but I think you pointed out the issue, and that is one of management. The growth of consumption of seafood in this country and the world is so tremendous that if we can manage and balance these interests, really that is the bottom line here, if you will. So although aquaculture in your view could pose a threat to the water and so forth, you have clearly articulated a complementary role for both developments. Is that basically true?

Mr. WEBSTER. Yes, indeed.

Mr. McMILLEN. So in essence, I mean, you don't really feel threatened by aquaculture if it is managed with this kind of sensitivity?

Mr. SIMNS. It is all in the planning. If the planning is long-range, and you look at areas and you see what aquaculture would do in that area, if it is going to interfere with commercial watermen or if it is going to degrade the area through pollution and there is a lot of natural product there, then you don't use that area.

But there are plenty of areas in the Bay that wouldn't be harmful either to the commercial watermen or to the natural species, and those are the areas that would be best suited for aquaculture. I think planning is the whole key, and that is really what we have been trying to do in opposing some of the wild legislation that went in. We have been very successful with the Maryland Legislature to pull out the parts that were too wide-open and tighten it up a little bit.

Right now I think that we are very close, in the Aquaculture Committee, to an agreement. In fact, we had a bill that we all agreed on but the lawyers for the Department, I believe it was, got it all messed up so we had to pull part of it out. I'm sure you understand all that, but I think that we are very close to being in a cooperative, working together situation where everybody can benefit and nobody lose by it.

Mr. McMILLEN. Let me ask you to comment on the concern that the Governor had about not allowing this industry to be taken over by corporate giants. In Washington and Oregon, for instance, in the salmon fishing area you saw a number of major corporations come in there and take over the salmon fishing, if you will—Campbell's Soup, Weyerhaeuser, a whole number of companies. After having observed that experience in Washington and Oregon, the

State of Alaska took a different tack and passed some nonprofit legislation to encourage entrepreneurs and nonprofits in this area.

What are your thoughts on how we can energize the entrepreneur, energize the small business sector, energize the watermen in this area, so it doesn't become institutional or so corporate in scope?

Mr. WEBSTER. I think if you look at the Pacific Northwest right now, a lot of those big companies that were involved in aquaculture out there are not now, or they have moved. Certainly Campbell's is one. After having bought Domsea, then they moved into Idaho. This has gone on for years, the myth that Campbell's Soup is sitting out there waiting to lease up the Chesapeake Bay.

In the conference summary from last year you will see remarks from Cary Monaghan, a marketing director from Campbell's. We put the question to him, what did Campbell's want on the Chesapeake Bay? He said, "We don't." He said, "What we want and what we will probably do," he said, "you look at chicken and vegetables. We don't produce. We want to buy from producers. We want to buy from the farmers. We want to buy from the people who are producing these things. We have made our money in the processing, marketing, and distribution."

The areas where the big corporations have gotten into food production have not worked out as well as the individual farmer, and I think you can certainly say the individual waterman who may get involved with either oyster farming or with finfish in the future. Certainly those are the people with whom we are working on a daily basis, both with oysters, and with clams over on the seaside, and with finfish around the Bay, are the small producers.

Mr. SIMNS. If I might add on that, the other thing is, in the legislation in Maryland we are trying to keep that to that point, where there will be enough bottom, if we are talking about leased bottom, that there would be enough to go around. The way to do that is to limit how much an individual or a corporation can lease, so that everybody gets a little piece of the action.

You will find that in the end you will produce a whole lot more when you have owner-operated aquaculture instead of having big companies, because it is very labor-intensive. You almost have to babysit with your product, and the guy that babysits with it the best has the best product and succeeds the best. When you get into big corporations, it just doesn't work. The big fear the watermen always had was big companies coming in and taking over and expecting them to work for them. They are individual businessmen. They don't work for other people.

We feel like we are on the right track. In the Chesapeake Bay, our watermen are owner-operators. They are not big company boats. Each person owns his own boat and operates his own. We foresee aquaculture as being the same way, and being more successful being that way than if it was big companies.

Mr. McMILLEN. But in an article that I am reading about "Fish Farming - A Clash Of Cultures," Larry, you point out that you liken this aquaculture industry to the poultry industry 25, 35 years ago. "Farmers who held fast to the notion that healthier animals are the free-roaming creatures in the barn yard were pushed out of business by the more efficient factory operators who raised live-

stock and poultry in confined quarters," and you pointed out that you saw the industry going to the Frank Perdues of the world, as it did in chicken.

Mr. SIMNS. That was one of the major worries, yes, and I think that was addressed in the Maryland Legislature, so that doesn't happen.

Mr. McMILLEN. So you think that has been worked out, and your view is that this Christopher Columbus Center can move forward in managing these interests and also helping aquaculture grow, so that we are not relying on imported seafood and the like?

Mr. SIMNS. Yes, and one of the things I really think is central, the one big thing that I see, I see a lot of people—and I will use the people I represent, watermen— getting involved in aquaculture, and if they can just go anywhere and set up their aquaculture operation, then lots of them are going to fail because certain areas aren't suitable for it. If you had an aquaculture center that was going to look at what is needed, what type of water and what kind of bottom, what kind of area, tide flow and all that, then they would have a more educated guess as to where to start their operation. If we hadn't followed through like 3 years ago when the first bill came up, they would have allowed anybody to go anywhere and lease the bottom and start, and you would have seen lots and lots of people go bankrupt and they would have left a total mess in the Bay, but with the right planning — and I think this center fits in with that right planning, and also for disease control, so I think it is essential to have it.

One thing I might add that hasn't been brought up here about the reason this area is the best area for it, in the Chesapeake Bay in very short distances you can get all different types of salinities, different depths of water, different weather conditions, and you have all different temperatures, so you can therefore do studies in the Bay that represent anywhere in the United States. I think that you would be centrally located and all that, and I think everybody in the country will benefit by it, because your ocean is not too far away to do your ocean work, and then all the way up the Bay you get different salinities that would represent any body of water in the United States. I think that is the uniqueness of the Chesapeake Bay and having it in this area.

Mr. POWERS. If I could add to that for just a moment, as we talk about the interest in keeping aquaculture for not just the large corporations but for the small entrepreneur as well, one thing that Maryland has to offer, as is true of Virginia and other States around us, is the fact that we have such large population centers that will demand a variety of different kinds of marketing tools and channels to get the product to the people. We feel that because of the large number of manmade farm ponds that exist already in this area—for instance, getting away from the Bay for just a moment—that there will be a tremendous number of people raising very small quantities of fish, mom and pop type operations that could be analogous to the roadside market that you would see for vegetables, being sold to the consumer as they pass down the road. I think that type of thing will happen here, as well as the high-tech type of million-pound and larger indoor recirculating systems that

we are now seeing a lot of interest in Maryland. I think that is very important.

The other thing, too, that we are doing in Maryland that I think is unique, as a matter of fact I know that it is in the United States. Because of our concern for the Chesapeake Bay and our interest in environmental concerns with aquaculture, we do not want aquaculture to contribute further to the pollution of the Bay. So this year for the first time, starting in July of this year, we will have matching funds that are available from the State government for aquaculturists to try to design and build water treatment facilities for aquaculture alone, so that the water going back into the rivers and the streams and the Bay will be as good as what came out.

Mr. McMILLEN. Mr. Chairman?

Mr. SCHEUER. The Israelis are very much concerned about the environmental effects of aquaculture, because fish don't stop emitting the usual excreta when they are artificially bred and nurtured as they did in their normal state, so when you have a large quantity of fish in a small area, the pollution of the fish's own excretions becomes a very serious problem.

I detect a sort of feeling here that there is a little built-in conflict between the fishermen and the fish farmer. Is there a conflict? Can the average fisherman become a fish farmer? What are the threats? What are the risks? What kind of capital assistance or hand-holding or nurturing does a fisherman need to become a successful fish farmer? How can the fishing industry or fishermen sort of phase into aquaculture so that they are successful fish farmers?

Mr. POWERS. There is, I think, and has been an innate concern between watermen or fishermen and aquaculturists. There is also an innate concern between the traditional farmer and the aquaculturist. As we talk to people who are vegetable producers, they in many cases have the same type of concerns that the watermen do, especially as we relate, if we talk about the broiler industry—we are still talking about chickens—and the idea that fish can be a major source of protein for human beings in the future, we have that concern as well.

As far as what can happen, we believe that in Maryland or Virginia, surrounding the Chesapeake Bay where we have, I believe, the largest concentration of commercial fishermen in the country, that through demonstration and through cooperation we can be able to teach and educate not only farmers but watermen alike in the methods for growing fish rather than just harvesting them. Some of that type of thing is already underway, as Mr. Webster said, working with remote setting of oysters, and some of the other types of programs underway right now.

One of the things that—as aquaculture coordinator for the State—that I am very concerned with is education and training for individuals who are interested in aquaculture. Conferences and workshops, such as what we are trying to do with the two States right now, are one way to approach that. I would like to say that the watermen are a very major, integral part of the Aquaculture Advisory Committee. They serve on the committee, and not just one but I think you actually have two or three representatives involved. Consequently, we do hear them and we are interested in their concerns and we try to address those.

Mr. SCHEUER. Well, what are their concerns? How do they feel threatened? How do they feel they are at risk?

Mr. SIMNS. I can explain a lot of that. One thing is that watermen are harvesters and not growers, and so it is a major switch for them to do that. The other thing is that watermen don't own any land. They own boats and equipment, harvesting equipment, and most of the time the harvesting equipment that we have is equipment that is not the most efficient equipment, because in Maryland we legislate inefficiency to keep from overharvesting the stocks. Most of our equipment wouldn't be the equipment that you would use to harvest on leased land, because on leased land you are allowed to use anything you want and you use the most efficient method.

Consequently, you have a person that has a lot of money tied up in equipment, that a lot of it is not going to be good in his aquaculture project. The thing of it is, it takes time for things to work. When you try to do things too fast, that is when the fear arises that everything is going to be done wrong and they are going to get left out. It is a major fear that if you go too fast, they will get left out, because other people that have more money to invest in leasing the bottom and putting seed on it, or net pens or whatever you are going to do, will take that money and invest, and the waterman who is trying to struggle to survive, he won't have the money to invest.

So it is an educational type thing. We have a lot of watermen that have survived through lots of crises because they do think ahead and they are willing to try new things. They will be the watermen that will do the aquaculture, but there is still going to be a majority of watermen that are always going to be harvesters, and that is why we don't want one to conflict with the other.

I think the major thing is hesitation, and also they are going to need financial support, because the big problem with aquaculture in the Bay system is that the gamble, the risk there is very high. Let's say you lease bottom. If you lease a piece of bottom where the lease doesn't cost much, but when you go to plant the seed oysters on it, the shells that you need to make it an oyster-producing bottom, that cost is very high and it is going to take 2 to 3 years before you get a return on that investment, and each year you are going to have to invest again so that you have a following return on your investment coming.

Well, in three years' time, suppose we have a natural disaster and it wipes you out, and you are just a little individual businessman. You are out of business forever because you can never borrow to get back in that business. It is a high-risk business. It is not the panacea that is going to solve all the problems, so that's why we need to take our time planning and also to get Government assistance to get it started, but if we just get Government assistance right away and give everybody a certain amount of money to go do it, then you are going to throw your money away. We need the planning first and then the Government assistance second. It just takes a little longer than a lot of people would like, to see it happen, but I can assure you it will be a lot better and more productive if we take that time.

Mr. WEBSTER. I can say we have had places in Maryland where a lot of small watermen have had State oyster leases in the past. In your district, Congressman, there have been more lease applications since leasing has opened up in the last few years than there have been in many, many years. It is one of the few areas that is open now, and people are looking at it and they are willing to make that commitment.

I went to a fish expo, a big national fish expo in Boston last fall, and they had a panel on aquaculture. One of the fellows who was on that panel was a fellow named Bryan Carbox from up in Maine, who is a lobsterman. He integrated into his operation a net pen where he was raising trout, brook trout. It fit into his schedule very well. He would feed them when he went out in the morning. He would feed them when he came back from pulling his pots in the afternoon. It fit into his schedule for the year very well. It was a real nice operation. I think he was one that had it very well thought out. He was a good businessman, and he was the kind of a fisherman or waterman who can make it in aquaculture.

I will be honest with you. I don't know where the future of this thing is going. It may well turn out to be like the broiler industry, but to sit there and say that the Eastern Shore, the State of Maryland, or the American consumer is worse off because of people like Frank Perdue, I think is ridiculous. It changed the nature of agriculture on the Shore. It changed us from fruits and vegetables and got us into grain farming. It made a tremendous amount of changes. If we were still relying on people with backyard flocks, we would probably be paying \$5 a pound for chicken today, and we are not. When times were tough, I thanked God we had that kind of protein that we could buy for that kind of a price.

I don't know. I work in the field. I don't really know where it is going in the future, but I know it is going to happen regardless, and I think Maryland has a good opportunity to participate in the industry in several areas, and I think we are going to.

Mr. McMILLEN. You also have to remember that Frank Perdue started small, too—

Mr. WEBSTER. That's right.

Mr. McMILLEN.—and that's the real promise there.

One quick question as we close here: I am curious about the aquaculture centers, since we are in the middle of the country here, the one in the Southeast, in Mississippi, and the one in the Northeast, in Massachusetts. In your view, do you think those centers adequately cover the Mid-Atlantic region in terms of research?

Mr. WEBSTER. No. We are part, as I said, of the Northeast. The Northeast has got two major research programs going, one on hybrid striped bass which somebody from Maryland is the principal investigator on. We also participate in the one on oyster diseases.

We have problems when it comes to working with our sister State of Virginia, because they are in the southern region and the southern region has been almost purely, simply catfish, because that is what their interest is in Mississippi, and you certainly can't fault them down there. I think if we could carve out a Mid-Atlantic District, it would make things a lot easier to work together. We could work in projects and programs and problems that are more directed towards the States here in the Mid-Atlantic. We share the

Chesapeake Bay. I have said from time to time we seem to share a common zone with our neighbors in Virginia, but it would make things a great deal easier if we could have a Mid- Atlantic Center.

Mr. McMILLEN. I appreciate your thoughts on this. As you know, in the last several years we have been trying to get three-quarters of \$1 million for a Mid-Atlantic Center, and I hear your comment about Virginia is focusing on catfish and you are directed toward Massachusetts with the striped bass project. It would make more sense to have some sort of integration around the Bay region. We will continue to request those monies, hopefully, in the future.

I want to thank you all for your testimony for the record, and for your support of the Christopher Columbus Center. I think it is very, very important and very consistent with the National Aquaculture Development Act of 1980. It is a national policy to encourage aquaculture across our land, and your comments I think clearly point out how this center can enhance that and assist in your efforts. We want to thank all of the panelists, all of the witnesses, in concluding this hearing on the potential of agriculture and marine biotechnology and, of course, the role that the Christopher Columbus Center can play in that.

Mr. Chairman, I want to thank you for coming to Maryland once again on a very, very important subject, economically and environmentally and in lots of different ways for our State. We look forward to continued oversight in our Committee on Science, Space and Technology of these important issues for our State and for our country. Thank you, Mr. Chairman.

Mr. SCHEUER. It was an outstanding hearing, and this was a fine, outstanding, excellent professional panel. Thank you all.

Mr. McMILLEN. The hearing is adjourned.

[Whereupon, at 4:30 p.m., the subcommittee adjourned, to reconvene at the call of the Chair.]

